UNIVERSITY
OF MICHIGAN
DEC
ENGIN ING

Applied Mechanics Reviews

REVS. 1-351 VOL. 9, NO. 1 JANUARY 1956

GENERAL

Theoretical and Experimental Methods.. 5
Mechanics (Dynamics, Statics, Kinematics)..... 9

MECHANICS OF SOLIDS

Servomechanisms, Governors, Gyroscopics..... 11
Vibrations, Balancing..... 12
Wave Motion in Solids, Impact..... 15
Elasticity Theory..... 15
Experimental Stress Analysis..... 16
Rods, Beams, Cables, Machine Elements 17
Plates, Disks, Shells, Membranes..... 19
Buckling Problems..... 20
Joints and Joining Methods..... 20
Structures..... 21
Rheology (Plastic, Viscoplastic Flow)..... 22
Failure, Mechanics of Solid State..... 25
Material Test Techniques..... 25
Mechanical Properties of Specific Materials..... 26
Mechanics of Forming and Cutting..... 27

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport..... 28
Incompressible Flow: Laminar; Viscous.. 29
Compressible Flow, Gas Dynamics..... 31
Wave Motion in Fluids..... 32
Turbulence, Boundary Layer, etc..... 33
Aerodynamics of Flight; Wind Forces... 35
Aeroelasticity (Flutter, Divergence, etc.).. 37
Propellers, Fans, Turbines, Pumps, etc.... 38
Flow and Flight Test Techniques..... 38

HEAT

Thermodynamics..... 39
Heat and Mass Transfer..... 41
Combustion..... 44

MISCELLANEOUS

Acoustics..... 45
Ballistics, Detonics (Explosions)..... 46
Soil Mechanics, Seepage..... 46
Micromeritics..... 47
Geophysics, Meteorology, Oceanography..... 47
Lubrication; Bearings; Wear..... 47
Marine Engineering Problems..... 48
Biomechanics..... 48

Books Received, 5

Electroanalogic Methods (Part 1), Thomas J. Higgins, 1

Published Monthly by
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS
at Easton, Pa., and edited by
Southwest Research Institute with the
co-operation of Linda Hall Library

APPLIED MECHANICS *Reviews*

Under the Sponsorship of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS • THE ENGINEERING FOUNDATION • SOUTHWEST RESEARCH INSTITUTE • OFFICE OF NAVAL RESEARCH • AIR RESEARCH AND DEVELOPMENT COMMAND • NATIONAL SCIENCE FOUNDATION

Industrial Subscribers

GENERAL ELECTRIC COMPANY • INTERNATIONAL HARVESTER COMPANY • M. W. KELLOGG COMPANY
GENERAL MOTORS CORPORATION • SHELL DEVELOPMENT COMPANY • WESTINGHOUSE ELECTRIC CORPORATION

EDITOR	Martin Goland
EDITORIAL ADVISERS	H. L. Dryden T. von Karman S. Timoshenko
EXECUTIVE EDITOR	S. I. Juhasz
ASSOCIATE EDITORS	J. C. Shipman Isao Imai J. J. Jaklitsch, K. Zarankiewicz H. Norman Abramson
ASSISTANT EDITORS	L. Bosch L. Graf J. Demmer S. Lechtman E. Gindorf H. K. Wilgus
PUBLICATIONS BUSINESS MANAGER	S. A. Tucker
OFFICERS OF ASME	J. W. Barker, *President* J. L. Kopf, *Treasurer* C. E. Davies, *Secretary*
AMR MANAGING COMMITTEE	R. B. Smith, *Chairman* R. E. Peterson R. D. Mindlin (*ex officio*) H. Vagtborg N. M. Newmark F. J. Weber C. Yost

Editorial Office: **APPLIED MECHANICS REVIEWS, Southwest Research Institute, 8500 Culebra Road, San Antonio 6, Texas, U. S. A.**
Subscription and Production Office: **The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., U. S. A.**

HOW TO OBTAIN COPIES OF ARTICLES INDEXED: Photocopy or microfilm copies of all articles reviewed in this issue will be provided on request. Orders should specify the APPLIED MECHANICS REVIEWS volume and review number; should be addressed to LINDA HALL LIBRARY, 5109 Cherry St., Kansas City 10, Mo., and be accompanied by a remittance to cover costs. Where desirable, photocopies and microfilm may be obtained by teletype, using the number KC334 (call number of LINDA HALL LIBRARY). Photocopy costs are 35c for each page of the article photocopied; minimum charge, $1.25. Microfilm costs include service charge of 50c per article, plus 3c per double page; minimum order, $1.25. *(Applicant assumes responsibility for questions of copyright arising from this copying and the use made of copies. Copyright material will not be reproduced beyond recognized "fair use" without consent of copyright owner.)*

APPLIED MECHANICS REVIEWS, January 1956, Vol. 9, No. 1. Published monthly by The American Society of Mechanical Engineers at 20th and Northampton Streets, Easton, Pa., U. S. A. The editorial office is located at the Southwest Research Institute, San Antonio 6, Texas, U. S. A. Headquarters of ASME, 29 West 39th St., New York 18, N. Y., U. S. A. Cable address: "Dynamic," New York. Price $2.50 per copy, $25.00 a year; to members of ASME $1.00 per copy, $10 a year. Changes of address must be received at Society headquarters seven weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Laws: The Society shall not be responsible for statements or opinions advanced in papers or printed in its publications (B13, Par. 4). . . . Entered as second-class matter, January 11, 1948, at the Post Office at Easton, Pa., under the Act of March 3, 1879.
Copyrighted, 1955, by The American Society of Mechanical Engineers.

APPLIED MECHANICS REVIEWS

VOL. 9, NO. 1 MARTIN GOLAND *Editor* JANUARY 1956

ELECTROANALOGIC METHODS

1 *Solution of electrical problems by continuous-type conductive procedures*

THOMAS J. HIGGINS

DEPARTMENT OF ELECTRICAL ENGINEERING, UNIVERSITY OF WISCONSIN, MADISON, WIS.

THE efficacy of analogic experimental methods stems from Maxwell's dictum: "The similarity which constitutes the analogy is not between the phenomena themselves, but between the (mathematical) relations of these phenomena."

Thus, let each of n diverse physical phenomena be formulated as a boundary-value problem in mathematical terms through specification of an array of partial differential equations and prescribed boundary conditions, this array couched in terms of pertinent functions $(F_{i1}, F_{i2}, \ldots)$ of the generalized independent variables $(x_1, x_2, \ldots)$. If it ensues that mathematically these n arrays are formally identical, it follows: (i) that each set g_i-$(i = 1, \ldots, n)$ of the n sets of functions $g_i = (F_{i1}, F_{i2}, \ldots; f_{i1}, f_{i2}, \ldots)$—the f_i being derived from the F_i by specified mathematical operations—is identical in the coordinates $(x_1, x_2, \ldots)$; (ii) that the physical quantities symbolized by the members of the sets $(g_1, \ldots, g_n)$ are analogous to each other in that corresponding members of the sets (F_i, f_i) are analogs; and (iii) that the magnitudes of the physical quantities symbolized by the elements of a particular set $(F_{i1}, F_{i2}, \ldots, f_{i1}, f_{i2}, \ldots)$ relative to a particular phenomenon in a particular state can be interpreted as magnitudes of analogous quantities relative to any of the other $(n - 1)$ phenomena in the same (analogous) state.

Thus, should it happen that a problem to be investigated quantitatively is intractable both to exact mathematical analysis and to direct experiment, and that investigation by approximate mathematical methods is not feasible because, say, of the labor involved, the time required, or both; whereas experimental investigation of an "analogous phenomenon" can be effected both quickly and easily; then investigation of the original problem through analogic experiment would be the obvious course to pursue.

Such is exactly the case in various domains of technology and applied science: whence it follows that an extensive knowledge of pertinent analogic methods is a valuable asset to the engineer or scientist working in one or more such domains. Now among analogic methods, continuous-type *conductive* electroanalogic procedures—as exemplified in electrically conducting tank, plate, sheet, or liquid surface procedures—hold a preferred position. The apparatus required is relatively simple in nature, readily constructed, inexpensive to maintain, easy to use, furnishes results of good or excellent accuracy, and—not least—is flexible in application. Yet, despite such merit, no truly inclusive exposition of conductive electroanalogic methods is to be found in books; nor is other than limited mention made therein of original sources wherein such exposition is to be found.

This article, however, encompasses a multitude of such sources. And in that these furnish an exhaustive coverage of modern conductive electroanalogic procedures, available for effecting accurate quantitative solution of two-dimensional and rotationally symmetric three-dimensional boundary-value problems in every domain of engineering and applied science, especial interest may attend the following inclusive account of informational sources and varied applications of conductive electroanalogic methods.

1 GENERAL

The general basis of analogic efficacy, as remarked in the first paragraph of the introduction, is well-evidenced by the numerous different types of procedures and domains of application detailed in Soroka's (1)[1] recent book. A succinct epitomization of the analytic correlation of different physical phenomena through their mathematically similar differential equations and boundary conditions is advanced in an earlier paper (2). The particular merits, diversity of procedure, wide applicability, varied physical form, and international utilization of conductive electroanalogical methods are well-encompassed in general writings by Farr and Wilson (3), Peres and Malavard (4, 5), Germain (6), Gentilini (7), and Dadda (8, 9).

2 ELECTRIC FIELDS

In point of chronology, the use of conductive analogic procedures dates from at least 1845 (Kelvin may have known such a bit earlier). In this year Kirchhoff (10) utilized the analogy between current flow in an isotropic uniformly thick homogeneous metallic plate and flux distribution between charged parallel linear conductors in a uniform medium to effect values of the capacitance between certain configurations of such conductors. Subsequently, Quincke (11), Smith (12)—who was among the first to suggest use of a conducting electrolytic solution rather than a metallic plate—Foster and Lodge (13), Adams (14), and Kirchhoff (15)—to remark only some of the most fruitful early work—made extensive analytic and experimental studies of the electric field configurations produced by point and line electric charges (and magnetic poles).

The later extension of interest to the fields associated with rotating machines and other electric apparatus, and the diversity

[1] Numbers in parentheses indicate References at end of paper.

of utilization therefore is well demarked in the qualitative accounts of Hague (16), Say (17), Liebmann (18), Schmidl (19), Diggle and Hartill (20), and in the excellent analytic paper by Hartill (21).

Green (22) has detailed numerous methods for plotting electrostatic fields (as developed up to 1945). A major field of use is that of determination of the electric fields associated with high-voltage equipment: insulators (23), multiphase cables (24, 25, 26), switchgear (27), transformers (28–34), ground electrodes (35, 36), precipitators (37), and yet otherwise (19, 20). Derived quantities, such as the voltage gradient of fields or the capacitances of lines or busses, of interest in the study of insulation stress or of power distribution performance, can be calculated from the directly determined flux and potential distributions; but direct determination of the mentioned quantities of interest is possible (though not as well known), and is usually preferable as affording better accuracy (26, 38, 39, 40). Again, though most of the cited work is concerned with fields whereof the dielectric structure is homogeneous, determination in domains encompassing variable or graded dielectric constants is yet feasible—as is evidenced in several recent excellent studies of stress concentration in solid dielectrics (41, 42) and of other connection (18, 19).

3 ELECTROLYSIS

Ahmed's (43) study of field distribution in an electrolytic cell comprises an early (1925) instance of the usefulness of electroanalogic investigation in electrolysis. The spread of application is manifested in the recent investigations of: the shaping of electrodes to yield uniform current density over their surfaces (44, 45); the best shape of probe for use in measurement of polarization (46); the density of current in the region of a meniscus *re* optimum electrolytic pointing of electrodes (47, 48); and yet other facets of interest, as effected both by electrolytic tanks and —more easily and effectively—by the conducting-paper apparatus developed by Meunier and Germain (48).

4 MAGNETIC FIELDS

The accurate mapping of magnetic fields produced by magnetic material and current-carrying conductors, either separately or in conjunction, comprises a domain of application which is of especial current interest: in connection with the optimum design of conductors and coils carrying large currents (3, 21, 49); large rotating electric machines (16, 50)—classic, yet important instances of use; and large-scale atomic-particle accelerators and associated equipment (51, 52, 53).

As much of such apparatus possesses rotational symmetry, electroanalogic investigation thereof requires somewhat different shapes of conducting apparatus than for planar fields. Excellent general reviews of this subject are comprised in papers by Hartill (21), Striegel (54), and Dadda (55). Special types of tanks therefor are detailed by Peierls (51, 52), Germain (56), Hahnemann and Ehret (57), and others remarked below.

5 ELECTRIC NETWORKS

Cherry (58) has written a very excellent tutorial paper on electroanalogic procedure as a powerful auxiliary aid in modern circuit theory: for determining frequency-response characteristics, evaluating transient performance, and ascertaining dissipative effects in circuit elements; effecting pertinent mathematical operations such as conformal transformation, factorization of polynomials, and inverting Laplace transforms; and for carrying out yet other procedures of interest in modern electric circuit analysis and synthesis. An early application of such is that of rapid determination of the frequency transfer functions of amplifiers, filters and other networks having specified poles and zeros: both from Darlington's insertion loss approach (59, 60) and Zobel's image parameter method (61, 62).

Some of the earliest work (59) was effected in tanks having conducting areas of finite size, whereas theory predicated use of an infinitely extending plane. The error incident to this shortcoming can be lessened by appropriate use of correction factors (59), or obviated by use of arrangements based on suitable conformal transformations, such as the logarithmic scheme suggested by Huggins (60), the double-layer disk arrangement developed by Makar, Boothroyd, and Cherry (62, 63, 64), and the yet more general transformation used by Met (65).

Similar apparatus and procedure are, of course, immediately applicable in the analysis and design of servomechanisms and other automatic control systems (66, 67).

The closely linked activity of analogic effectance of the analysis pertinent to Darlington's (68, 69) line-charge analog method of network synthesis has been accomplished for prescribed transient performance by Holmes (70, 71) and for prescribed gain-phase characteristics by Scott (72, 73).

In the analysis or design of network systems it is frequently necessary to effect the partial fraction expansion of a rational fraction, to find the zeros of a polynomial, or to determine a residue of a function of a complex variable. Indeed, a first use of the fundamental concept underlying the above-mentioned network uses—namely, Maxwell's (74) suggestion of representation of the real and imaginary parts of a function of a complex variable by the potential and stream lines in a conducting sheet—was utilized by Klein (75) as a means of effecting the Riemann-surface representation of multivalued functions of a complex variable. Of much present use is Lucas' (76) adoption of the idea for analogic factorization and root location of polynomial equations, as subsequently developed by a number of workers (62, 64, 67, 77–81). In particular, attention is to be directed to Tasny-Tschiassny's (78) excellent detailed account of the general analogic theory and of special pertinent techniques and to Salzer's complementary account of effecting Lucas' method digitally rather than analogously. Finally, a very good account of residue evaluation is encompassed in the papers by Boothroyd (62, 64, 67).

In conclusion of this section, especial mention should be made of Farr's (83) generalization of analogic conformal transformation techniques (84, 85) to the end that solution of a great variety of planar and rotational-symmetric problems can be effected by single or multiple tanks of special shape and design.

6 CHARGED-PARTICLE BALLISTICS

The determination of field distribution, electron trajectories, and means of improving performance of vacuum tubes comprises an important use of electroanalogic methods (86–90). Because of the considerable labor required to plot the numerous curves comprising a thorough study of a problem and the corresponding error that can result from computation based on these curves, much attention has been devoted to obtaining both a reduction of labor and an increase in accuracy and speed of performance by conjoining the analog device with automatic plotting equipment (91–95). Thus, through use of a dual-mode servo arrangement, one of the most recently described apparatus affords rapid, accurate plot of both field distribution and electron trajectories (96). Again, through use of an analogy between current flow and space charge effects, plot of the field and trajectories in the presence of space charge can be obtained (97, 98).

7 MICROWAVE APPLICATIONS

Electroanalogic methods find considerable use in the development of microwave apparatus. Thus, cavity parameters, such as the resonant wave length and the Q, of axially symmetrical cavities were obtained by Bertram (99) through use of data taken in an electrolytic tank—and the same procedure is applicable to other mathematically difficult structures such as ridged

wave guides. Again, use of two appropriately shaped conducting plates separated by a sheet of low-loss dielectric and driven by an a-c source furnishes data on the principal mode of operation of a cylindrical wave guide of arbitrary cross section (100).

In the area of microstrip line design, Duke (101) has substantiated by electrolytic tank measurements the correctness of the expression for the characteristic impedance of open-strip lines effected by Black and Higgins (102).

The conductive, dielectric, and magnetic constants of obstacle-type artificial media (103), much used in the construction of certain microwave transmission apparatus, can be determined by use of data obtained by various analogic approaches (104). In particular, Cohn has made considerable use of the electrolytic tank for such purpose (105–108). In a similar fashion, Pearce (109) has ascertained values of the conductive and dielectric constants of mixtures such as emulsions of water in fuel oil.

8 CLOSURE

Finally, the interesting study of junction shape and surface recombination on transistor circuit gain, as determined first by a planar conducting paper analog and subsequently and more satisfactorily by a three-dimensional electrolytic tank, is to be noted (110–111).

In closure of this account of electroanalogic solution of problems of electric and magnetic nature, it may be remarked that part II comprises account of the solution of elastic, thermal, hydrodynamic, and aerodynamic problems.

REFERENCES

1 Soroka, W. W., Analog methods in computation and simulation, New York, McGraw-Hill Book Co., Inc., 1954, 390 pp.; AMR **8**, Rev. 1537.

2 Soroka, W. W., Experimental aids in engineering design analysis, *Mech. Engng.* **71**, 831–837, Oct. 1949.

3 Farr, H. K., and Wilson, W. R., Some engineering applications of the electrolytic field analyser, *Trans. AIEE* **70**, part II, 1301–1309, 1951.

4 Peres, J., and Malavard, L., Rheographic and rheometric analog methods (in French), *Bull. Soc. Fr. Elec.* (5) **8**, 715–744, 1939.

5 Surugue, J., General techniques of physics laboratory [Technique Générales du Laboratoire de Physique], vol. II, Paris, Edition of CNRS, 1950. Malavard, L., Electric analogy technique [La techniques des analogies electriques], chap. 15.

6 Germain, P., Electric analog methods for the study of problems related to the Laplace equation (in French), *La Revue H. F.* **2**, 9, 1954.

7 Gentilini, B., The method of electrical analogy and some recent applications (in Italian), *Energia elett.* **26**, 461, 1949.

8 Dadda, L., Experimental study of flow lines in a plane harmonic field (in Italian), *L'Ele'trotecnica* **26**, 367–375, 1949.

9 Dadda, L., Electrolytic tank at the center for electric analog methods (in Italian), *Energia elett.* **28**, 23, 1950; Admiralty ACSIL translation no. 594.

10 Kirchhoff, G., Flow of an electric current through a plane, particularly through a circular disk (in German), *Ann. Phys. und Chemie* **64**, p. 499, 1845; **67**, 1846; Gesammelte Abhandlungen, pp. 1–17 and 17–22, 1882.

11 Quincke, G., Distribution of electric current in metal sheets (in German), *Ann. Phys.* **7**, 382–396, 1856.

12 Smith, W. R., On the flow of electricity in conducting surfaces, *Proc. roy. Soc. Edinburgh* **8**, 79–99, 1872.

13 Foster, C., and Lodge, O. J., On the flow of electricity in a uniform plane conducting surface, *Phil. Mag.* **49**, 385–400, 453–471; **50**, 475–489, 1875.

14 Adams, W. G., On the forms of equipotential curves and surfaces and lines of electric force, *Proc. roy. Soc. Lond.* **23**, 280–284, 1875.

15 Kirchhoff, G., Stationary electrical flow in a curved conducting surface (in German), Monatsbericht Akad. Wiss. Berlin, July 19, 1875; Gesammte Abhandlungen, pp. 56–66, 1882.

16 Hague, B., Analytic and graphic methods and experimentals for the study of magnetic and electrical fields in electrical machines and apparatus (in French), *Comptes Rendus du Congress Int. d'Elec.* **1**, sec. 3, 47–111, 1932.

17 Say, M. G., Analogies, *Bull. elec. Eng. Ed.*, no. 1, 7–16, 1948.

18 Liebmann, G., Electrical analogues, *Brit. J. appl. Phys.* **4**, 193–200, 1953. AMR **7**, Rev. 384.

19 Schmidl, H., Application of the electrolytic tank for the solution of problems in power engineering (in German), *Elek. ü. Masch.* **70**, 14, 309–316, 1953.

20 Diggle, H., and Hartill, E. R., Some applications of the electrolytic tank to engineering design problems, *Proc. IEE* **101**, part II, 349–364, discussion 364–369, 1954; discussion, **102**, part B, no. 4, 447–452, July 1955.

21 Hartill, E. R., The analogy between the flow of current in the electrolytic tank and the electric and electromagnetic field, *Bull. elec. Engng. Ed.*, no. 8, 42–54, May 1952.

22 Green, P. E., Methods of plotting electrostatic fields, *Engng. School Bull. N. Carolina St. Coll.*, no. 45, June 1945.

23 Estorff, W., Measurement of electrostatic fields of insulators by means of electrolytic methods (in German), *ETZ* **39**, 53–55, 62–67, 76–78, 1918.

24 Kennelly, A. E., and Whiting, S. E., On an approximate measurement, by electrolytic means, of the electrostatic capacity between a vertical metallic cylinder and the ground, *Elec. World* **48**, 1239–1241, 1906.

25 Emanueli, L., Experimental research on the distribution of the gradient of potential of three-phase conductors (in Italian), *L'Elettrotecnica* **8**, 573–580, 1921.

26 Atkinson, R. W., The dielectric field in an electric power cable, *Trans. AIEE* **43**, 600–620, 966–989, 1924.

27 Zschaage, W., Imitation of the electric field of conductors in an electrolytic tank, *ETZ* **46**, 1215–1219, 1925.

28 Peplow, M. E., *Elec. Times*, p. 256, Feb. 15, 1951.

29 Balachowsky, G., Note on the mapping of electric fields (in French), *Bull. Soc. Fr. Élec.* (6) **6**, 181–186, 1946.

30 Balachowsky, G., and Tirroloy, Utilisation of the electric tank in different problems concerning high-voltage equipment, C.I.G.R.E., Paris, Paper no. 132, 1950.

31 McDonald, D., Stenographic record of discussions: Utilisation of the electric tank, C.I.G.R.E., Paris, vol. **1**, p. 265, 1950.

32 McDonald, D., The electrolytic analogue in the design of high-voltage power transformers, *Proc. I.E.E.* **100**, part II, no. 74, 145–166; discussion, 176–183, Apr. 1953.

33 Hartill, E. R., The initial impulse-voltage distribution on a transformer winding, *Bull. elec. Eng. Ed.*, no. 10, 45–52, July 1953.

34 Carr, L. H. A., The determination of field potentials near corners, *Bull. elec. Eng. Ed.*, no. 13, 17–21, December 1954.

35 Rechberger, H., Mapping of ohmic resistances in the electrolytic tank (in German), *Elek. ü. Masch.* **70**, 345–347, 1953.

36 Schmidl, H., Principles of measurement for analog studies on grounding equipment (in German), *Elektrotechnische Zeitschrift* **75**, 17, 557–559, Sept. 1954.

37 Simond, A. W., and Kron, L. C., A quantitative experimental method of mapping equipotential lines and its application to electric precipitator problems, *Rev. sci. Inst.* **1**, 527–536, 1930.

38 Dadda, L., Direct determination in an electrolytical tank of the gradient in an electric field (in Italian), *Energia elett.* **26**, 469, 1949.

39 Miroux, J., Gradient measurements of rheoelectric analogies: apparatus for the direct determination of isovelocities (in French), *Rech. aero.*, no. 29, 9–20, 1952, AMR **6**, Rev. 1362.

40 Teasdale, R. D., and Higgins, T. J., Experimental determination of the capacitance of heavy-current busses comprised of solid or tubular rectangular conductors, *Trans. AIEE* **67**, 653–659, 1948.

41 Weston, K. X., Some factors determining the performance of solid insulation, *I.E.E. Students quart. J.*, Mar. 1955; *J. Inst. elec. Eng.* **1**, 7, 464–465, July 1955.

42 Schmidl, H., Field measurements of plane and rotationally symmetric electrostatic fields in different dielectric media by the electrolytic tank (in German), Tech. in wissenschaftlichen Abhandlungen, Ausgabe E., 161, 1951; 10, 1952.

43 Ahmed, A. A., Theoretical and experimental study of the electric field in an electrolytic cell, *J. I.E.E.* **62**, 301–317, 1924.

44 Piontelli, R., Porta and Arduini, *Metallurgia ital.* **193**, 1947.

45 Meunier, L., Comptes Rendus de la II — Reunion du C.I.T.C.E., Milan, 1950, p. 242.

46 Piontelli, R., and Bianchi, G., Comptes Rendus de la II—Reunion du C.I.T.C.E., Milan, 1950, p. 379.

47 Pfann, W. G., *AIME Tech. Publ.* 2210, circa 1950.

48 Meunier, L., and Germain, P., Distribution of equipotentials in electrolytic tanks (in French), Comptes Rendus de la III—Reunion, 1952, pp. 1–11.

49 Müllner, F., Electrical mapping of magnetic vortex fields (in German), *ETZ* **50**, 1321–1323, 1929.

50 Ahmed, A. A., Investigation by electrolytic means of the magnetic leakage of salient poles, *World Power* **2**, 334–340, 1924; **3**, 91–99, 157–161, 218–222, 1925.

51 Peierls, R. E., Use of electrolytic tank for magnetic problems, *Nature* **158,** 831–832, 1946.

52 Peierls, R. E., and Skyrme, H. R., Tank model for magnetic problems of axial symmetry, *Phil. Mag.* **40,** 269–273, 1949.

53 Bracher, D. F., Thesis, University of Birmingham, 1950.

54 Striegel, R., Mapping of potential fields in the electrolytic tank (in German), *Arch. tech. Messen* **V,** 312–1, 1943.

55 Dadda, L., Electrolytic analog for the study of harmonic fields in axial symmetry (in Italian), *Energia elett.* **30,** 12, Dec. 1953.

56 Germain, C., Application of a rheographic tank in the study of systems of axial symmetry (in French), *Rev. gen. Elec.* **64,** 5, p. 263, May 1955; see also *Comptes Rendus Acad. Sci.* **240,** Jan. 24, 1955; 488–589, Feb. 7, 1955.

57 Hahnemann, H. W., and Ehret, L., Mapping of axial symmetrical potential fields in a new electrolytic tank (in German), *Forschung Ing. Wes.* **20,** 5, 141–144; no. 6, 171–177, 1954. Abridged in *Engineers Digest* **16,** 4, 147–149, Apr. 1955.

58 Cherry, E. C., An electrolytic tank as an aid to the study of linear electric circuit theory, *Bull. elec. Eng. Ed.*, no. 7, 14–21, Nov. 1951.

59 Hansen, W. W., and Lundstrom, C. C., Experimental determination of impedance functions by the use of an electrolytic tank, *Proc. IRE* **33,** 8, 528–533, Aug. 1945.

60 Huggins, W. H., A note on frequency transformations for use with the electrolytic tank, *Proc. IRE* **36,** 421–424, Mar. 1948.

61 Klinkhamer, J. F., Empirical determination of wave-filter transfer functions with specified properties, *Philips Res. Rep.* **3,** 3, 60–80; no. 5, 321–400, 1948.

62 Boothroyd, A. R., Design of electric wave filters with the aid of the electrolytic tank, Proc. *IEE* **98,** part IV, Monograph no. 8, 65–93, 1951.

63 Makar, R., Boothroyd, A. R., and Cherry, E. C., An electrolytic tank for exploring potential field distributions, *Nature* **161,** 845–846, May 29, 1948.

64 Boothroyd, A. R., Cherry, E. C., and Makar, R., An electrolytic tank for the measurement of steady-state response, transient response and allied properties of networks, Proc. *IEE* **96,** part I, no. 99, 163–177, 1949.

65 Met, V., An electrolytic tank for the solution of network problems (in German), *Frequenz* **9,** 2, 57–63, Feb. 1955.

66 Daniell, P. J., Analogy between the interdependence of phase-shift and gain in a network and the interdependence of potential flow and current flow in a conducting sheet, Ministry of Supply Servo Lib., Great Britain, Ref. B. 39, 1942.

67 Boothroyd, A. R., and Westcott, J. H., The application of the electrolytic tank to servo-mechanism design, Automatic and Manual Control, Buttersworths Scientific Publications, London, England, pp. 87–103, 1952, AMR **5,** Rev. 3020.

68 Darlington, S., The potential analogue method of network synthesis, *Bell Syst. tech. J.* **30,** 315–365, Apr. 1951.

69 Fano, R. M., A note on the solution of certain approximation problems in network synthesis, *J. Franklin Inst.* **249,** 3, 189–205, Mar. 1950.

70 Guillemin, E. A., The mathematics of circuit analysis, New York, John Wiley and Sons, Inc., 1949, pp. 351–360.

71 Holmes, D. D., The dipole potential analog and network synthesis, M. S., thesis, Dept. Elec. Engng., M.I.T., 1950.

72 Scott, R. E., An analog device for solving the approximation problem of network synthesis, *Res. Lab. Electronics, M.I.T. tech. Rep.* no. 137, pp. 1–17, June 8, 1950.

73 Scott, R. E., Network synthesis by the use of potential analog, *Proc. IRE* **40,** 8, 970–973, Aug. 1952.

74 Maxwell, C., A treatise on electricity and magnetism, 1st ed., vol. II, 1873; 3rd ed., vol. II, art 647–651, Oxford Univ. Press, 1892. AMR **8,** Rev. 15.

75 Klein, F., On Riemann's theory of algebraic functions and their integrals: a supplement to the usual representation, "Gesammelte Mathematische Abhandlungen," Vol. III, Berlin, Julius Springer, 1881, pp. 506–573.

76 Lucas, F., Solution of equations by electricity (in French), *Comptes Rendus* **106,** pp. 33, 121, 195, 268, 587, 645, 1072; 1888.

77 Bloch, A., Solution of algebraic equations by means of an electrolytic tank, Proc. seventh int. Cong. appl. Mech., London, Pap. no. IV–28, 1948; AMR **3,** Rev. 1834.

78 Tasny-Tschiassny, L., and Doe, A. G., The solution of polynomial equations with the aid of an electric tank, *Austral. J. sci. Res.* (*A*) **4,** 231–257, 1951; AMR **5,** Rev. 1609.

79 Vieira, R. de C., Utilization of logarithmic potential analogs for obtaining the roots of polynomials by means of the electrolytic tank (in Italian), *Rev. Politecnica*, 83–88, July–Aug. 1952.

80 Orsini, L. de Q., and Vieira, R. de C., An electrolytic tank for the study of circuits and fields, Proc. Symp. New Research Techniques in Physics, July 15–19, 1952; Rio de Janeiro, 1954, pp. 389–394.

81 Wescott, J. H., Ph.D. thesis, University of London.

82 Salzer, H. E., On calculating the zeros of polynomials by the method of Lucas, *J. Res. nat. Bur. Stands.* **49,** 133–134, 1952; AMR **6,** Rev. 1958.

83 Farr, H. K., and Keen, W. A., Improving field analogues through conformal mapping, Communications and Electronics, no. 19, 395–400, July 1955.

84 Bradfield, K. N. E., Hooker, S. G., and Southwell, R. V., Conformal transformation with the aid of an electrical tank, *Proc. roy. Soc. Lond.* (A) **159,** 315–346, 1937.

85 Gandy, R. W. G., and Southwell, R. V., Relaxation methods applied to engineering problems: conformal transformation of a region in plane space, *Phil. Trans. roy. Soc. Lond.* (A) **238,** 456–475, 1940.

86 Barkhausen, H., and von Bruck, J., Shape of the electrical fields in electronic tubes, measured in the tank (in German), *ETZ* **54,** 175–177, 1933.

87 Hepp, G., Mapping of potential fields in the electrolytic tank (in German), *Phil. tech. Rev.* **4,** 223–230, 1939.

88 Himpan, J., A modified electrolytic tank for mapping of potential fields (in German), *Die Telefunkenröhre* **17,** p. 198, 1939.

89 Himpan, J., An improved electrolytic tank (in German) *ETZ* **63,** 349, 1942.

90 Hutter, R. G. E., Electron beam deflection—applications of the small-angle deflection theory, *J. app. Phys.* **18,** 797–810, 1947.

91 Sander, F. K., Oatley, C. W., and Yates, J. G., Factors affecting the design of an automatic electron-trajectory tracer, *Proc. IEE* **99,** part III, 169–179, 1952.

92 Barker, B. O., Automatic electron trajectory plotting using the electrolytic tank analogue, *Brit. J. app. Phys.* **5,** 191–195, 1954.

93 Bowman-Manifold, M., and Nicoll, F. M., Electrolytic field-plotting trough for circularly symmetric systems, *Nature* **142,** p. 39, 1938.

94 Sponsler, G. C., An automatic electron-trajectory tracer study of helix and band-type post deflection acceleration, *Tech. Rep.* no. 64, Lincoln Laboratory, M.I.T., May 26, 1954.

95 Sponsler, G. C., Trajectory-tracer study of helix- and band-type post deflection acceleration, *J. appl. Phys.* **26,** 6, 676–682, June 1955.

96 Logan, B. F., Welti, G. R., and Sponsler, G. C., Analogue study of electron trajectories, *J. Assn. Comput. Mach.* **2,** 1, 28–41, Jan. 1955.

97 Hollway, D. L., The determination of electron trajectories in the presence of space charge, *Austral. J. Phys.* **8,** 1, 74–89, Mar. 1955.

98 Hollway, D. L., An electrolytic-tank equipment for the determination of electron trajectories, potential and gradient, *Proc. IEE*, Pap. no. 1837 M, part B.

99 Bertram, S., Calculation of the resonant properties of electrical cavities, *Proc. IRE*, **42,** 3, 579–585, Mar. 1954.

100 Clement, P. R., and Johnson, W. C., A distributed electrical analog for wave-guides of arbitrary cross section, *Proc. IRE* **43,** 89–92, Jan. 1955.

101 Dukes, J. M. C., Characteristic impedance of air-spaced strip transmission line, *Proc. IRE* **43,** 7, 8–76, July 1943.

102 Black, K. G., and Higgins, T. J., Rigorous determination of the parameters of microstrip transmission line, Trans. I.R.E. Prof. Group on Microwave Theory and Techniques, M.I.T.-3, no. 2, 93–113, Mar. 1955.

103 Susskind, C., Obstacle-type artificial dielectrics for microwaves, *J. Brit. Inst. Radio Eng.* **12,** 49–62, Jan. 1952.

104 Swift, W. B., and Higgins, T. J., Determination of the design constants of artificial-dielectric uhf lenses by use of physical analogy, Proc. tenth nat. Electronics Conf., Chicago, Illinois, 1954, 825–832.

105 Cohn, S. B., Electrolytic tank measurements for microwave metallic delay-lens media, *J. appl. Phys.* **21,** 674–680, July 1950.

106 Cohn, S. B., The electric and magnetic constants of metallic delay media containing obstacles of arbitrary shape and thickness, *J. appl. Phys.* **22,** 5, 628–634, May 1951.

107 Cohn, S. B., Determination of aperture parameters by electrolytic-tank measurements, *Proc. IRE* **39,** 1416–1421, 1951.

108 Cohn, S. B., Microwave coupling by large apertures, *Proc. IRE* **40,** 697–699, June 1952.

109 Pearce, C. A. R., The electrical conductivity and permittivity of mixtures, with special reference to emulsions of water in fuel oil, *Brit. J. appl. Phys.* **6,** 113–120, Apr. 1950.

110 Moore, A. J., and Pankove, J. I., The effect of junction shape and surface recombination on transistor current gain—Part I. *Proc. IRE* **42,** 907–913, June 1954.

111 Stripp, K. F., and Moore, A. R., The effects of junction shape and surface recombination on transistor current gain—Part II. *Proc. IRE* **42,** 7, 857–866, July 1955.

Books Received for Review

ANDRES, P. G., MISER, H. J., AND REINGOLD, H., Basic mathematics for science and engineering, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, vii + 846 pp. $6.75.

DRAPER, C. S., MCKAY, W., AND LEES, S., Instrument engineering, vol. III, Applications of the instrument engineering method, part I, Measurement systems, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1955, xxviii + 879 pp. $17.50.

DUSCHEK, A., AND HOCHRAINER, A., Grundzuge der tensorrechnung in analytischer Darstellung, III. Teil: Anwendungen in physik und technik, Wien, Springer-Verlag, 1955, vi + 250 pp. $5.70 (paperbound).

FABER, O., Constructional steelwork, New York, Philosophical Library, Inc., 1955, xxiii + 368 pp. $12.

FLÜGGE, J., Das photographische Objektiv, Wien, Springer-Verlag, 1955, xiii + 373 pp. $16.45. (Die wissenschaftliche und angewandte Photographie, vol. I.)

GOLDENVEISER, A. L., Teoriya uprugikh tonkikh obolochek, Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1953, 544 pp. $5.88.

GREEN, W. G., Theory of machines, London, Glasgow, Blackie & Son, Ltd., 1955, xxi + 1034 pp. 40s, net.

GUGGENHEIM, E. A., Boltzmann's distribution law, London, Interscience Publishers, I td.; New York, Interscience Publishers, Inc.; Amsterdam, North-Holland Publishing Co., 1955, 61 pp. $1.50.

HECHT, F., editor, Bericht über den V. Internationalen Astronautischen Kongress, Innsbruck, 5. bis 7, August 1954, Wien, Springer-Verlag, 1955, vi + 307 pp. $13.80 (paperbound).

LELIAVSKY, S., Irrigation and hydraulic design, vol. I, General principles of hydraulic design, London, Chapman & Hall, Ltd., 1955, xiii + 492 pp. $25.

MANGHAM, E., AND PEACE, A., Jet engine manual, New York, Philosophical Library, Inc., 1955, 133 pp. $3.75.

Metallurgical Progress—2, A second series of critical reviews, New York, Philosophical Library, Inc., 1955, 71 pp. $6.

NOVOJILOV, V. V., Teoriya tonkikh obolochek, Leningrad, Gos. Izdat. Sudo. Lit., 1951, 344 pp. $4.

POUNDER, C. C., editor, Diesel engine principles and practice, New York, Philosophical Library, Inc., 1955, xiii + 820 pp. $17.50.

SMITH, G. G., Gas turbines and jet propulsion, 6th ed., Revised and enlarged by F. C. Sheffield, London, Iliffe & Sons, Ltd.; New York, Philosophical Library, Inc., 1955, 412 pp. $15.

Theoretical and Experimental Methods

(See also Revs. 40, 45, 46, 51, 55, 56, 57, 67, 68, 71, 73, 87, 97, 137, 153, 173, 198, 199, 211, 215, 237, 247, 279, 284, 290, 345)

1. Elsgolts, L. E., Ordinary differential equations [Obyknovenniye differentsialniye uravneniya], 2nd ed., Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1954, 239 pp.

This is a new edition of the fine elementary course in differential equations [see AMR 6, Rev. 13] and is of importance for many technical questions, e.g., theory of vibrations, stability of motion, etc.

The second edition of the book differs from the former, mainly in the following three points:

(A) Formal arrangements and various modifications in print were made with a view to raising the clarity and understanding of matters treated. In the first place, the book is printed in larger and more legible type; many relations and formulas are numerated and printed in separate lines. Secondly, the subject is better grouped into sections and natural wholes; e.g., the former §6 in chap. II is now divided into two paragraphs; some topics have obtained their proper title, etc.

(B) More exact formulation of many assumptions and theorems. Many comparatively complicated topics were rewritten and became much more readable to engineers (this refers particularly to §§6–8 in chap. IV).

(C) Author has added several valuable supplements. We expressly mention the six new pages at the end of §4, chap. III, applying matrix symbolics to formulating fundamental theorems in the theory of the sets of linear differential equations. The interesting and important problem of retarding argument (chap. IV, §9) covers now eight instead of the former three pages. The new edition concludes with a second appendix (nearly 4 pages) giving the proof of the famous Hurwitz stability criterion.

Paper and print are still better than in the edition of 1950 (in the cited Rev. 13, AMR 6, it is given erroneously as 1951). Reviewer agrees with the former review and recommends also this new edition to engineers and physicists.

V. Vodička, Czechoslovakia

2. Smirnov, M. M., Problems on differential equations of mathematical physics [Zadachi po uravneniyam matematicheskoi fiziki], Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1954, 87 pp. 1r. 35k.

This useful little book has been written with the purpose of completing by instructive examples the theoretical courses in differential equations of mathematical physics which now form a standard part of the program at physicomathematical faculties of the Russian universities. The collection contains 144 problems for solving, grouped into three separate sections.

The first part opens with a brief theoretical introduction and then gives 11 examples for reducing concrete differential equations to canonic form. The following section is devoted to solving the three fundamental problems in the theory of partial equations (i.e., the Cauchy, Goursat, and mixed problems) by the method of characteristics. It contains 45 partly physical and technical examples. Most important is the third part with a brief introduction and 88 problems from various branches of mathematical physics. The method to be applied in solving these examples is the well-known Bernoulli-Fourier separation of variables.

All problems are provided with solutions and, in more complicated cases, the way of solving is indicated. The collection is a valuable expedient not only for the students, but also for physicists and calculating engineers. V. Vodička, Czechoslovakia

3. Mishkis, A. D., Linear differential equations with retarding argument [Lineiniye differentsialniye uravneniya s zapazdivaiyushchim argumentem], Moscow-Leningrad, Gos. Izdat Tekh.-Teor. Lit., 1951, 255 pp.

This monograph originated in the author's dissertation and is designed for research workers in mathematics, physics, and mechanics. It presupposes only a reasonable working knowledge in advanced calculus and in the theory of ordinary differential equations.

The book deals with linear hystero-differential equations of the first and second orders. Modern developments in automatic regulation and other fields of applied science have greatly increased the importance of such equations. Despite its significance

in connection with practical purposes, the theory of differential equations with retarding argument has not been given a systematic study, and the volume under consideration is one of the few books on this subject.

Material is divided into five chapters with 35 subsections. The first and second chapters explain general theory of linear hysterodifferential equations and give some special properties of their solutions. Chaps. 3 and 4 deal with homogeneous linear equations of the first order of stable and unstable type. The last section treats homogeneous linear second-order equations of periodic type.

Volume concludes with four appendixes explaining some auxiliary notions from the theory of Stieltjes integrals, reversible sequences, and generalized linear differential equations with constant coefficients.

Book is of mathematical character and does not include technical applications. Nevertheless, it contains numerous literary data on practical use of equations with retarding argument and deserves, without any doubt, the careful attention not only of mathematicians, but also of engineers and physicists.

V. Vodička, Czechoslovakia

4. Dennis, S. C. R., and Poots, G., The solution of linear differential equations, *Proc. Camb. phil. Soc.* **51,** 3, 422–432, July 1955.

Authors discuss a method for the numerical solution of linear ordinary differential equations. In particular, a method is suggested for obtaining solutions of linear differential equations in the form of an approximate Fourier expansion with numerical coefficients over a specified finite range of integration. By means of the appropriate Fourier transform, the equation is reduced to an infinite set of linear simultaneous algebraic equations, and corresponding to each boundary condition, one further equation may be derived. The equations can then be solved to any desired degree of approximation by iterative methods or the relaxation method of R. V. Southwell. The method is first described for second-order equations and is then extended to equations of any order. Several examples are solved, and some techniques for accelerating the convergence of iterative procedures are suggested.

From authors' summary by E. L. Arnoff, USA

5. Vasil'eva, A. B., On differentiability of solutions of systems of differential equations containing small parameters with the derivatives (in Russian), *Vestnik Moskov. Univ. Ser. Fiz.-Mat. Estest. Nauk* **9,** 3, 29–40, 1954.

Let there be given a system

$$\mu\dot{z} = F(z, y, t)$$
$$\dot{y} = f(z, y, t) \qquad [1]$$

where z, F are n-vectors, y, f are m-vectors, and μ is a small parameter. Consider the associated degenerate system

$$F(z, y, t) = 0 \qquad [2'] \qquad\qquad \dot{y} = f(x, y, t) \qquad [2'']$$

it being assumed that [2′] is algebraic in z. Thus [2] may be replaced by a finite set of relations

$$\dot{y} = f(\varphi(y, t), y, t) \qquad [3]$$

It was proved in various papers [e.g., Vasil'eva, *Mat. Sbornik* (*N.S.*) **31(73)**, 587–644, 1952] that under certain conditions and for a certain range $(0, T)$ the solutions of [1] tend to certain solutions of [2]. In the last paper cited, author calculated the derivatives $dz(t, \mu)/d\mu$, $dy(t, \mu)/d\mu$ for μ small on the basis of Lyapunov's second method. The same result is now obtained in relation to Lyapunov's first method, i.e., in relation to the characteristic roots of the Jacobian matrix $[\partial F/\partial z]_{z=\varphi(y,t)}$. The result is extended to the case of several vectors z and as many variables μ.

S. Lefschetz, Mexico

6. Lax, P. D., Weak solutions of nonlinear hyperbolic equations and their numerical computation, *Comm. pure appl. Math.* **7,** 1, 159–193, Feb. 1954.

Author describes a modified version of a finite difference method proposed by von Neumann ["Proposals and analysis of a numerical method for the treatment of hydrodynamic shock problems," National Defense and Research Committee Rep. AM551, 1955] for the numerical solution of compressible flow problems involving shock waves. By transforming the hydrodynamic equations to the so-called conservation form (and by centering the difference equations in a specific manner,) author is apparently able to avoid the difficulties which are usually encountered in the application of this type of technique resulting from oscillations produced in the material motion following the passage of a shock wave.

The proposed procedure is illustrated by the solution of a number of numerical examples, carried out by means of a high-speed calculator.

H. Polachek, USA

7. Ödman, S. T. A., Studies of boundary value problems Part I. Minimum methods for solving semi-homogeneous boundary value problems, *Proc. Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol., Stockholm,* no. 20, 45 pp., 1953.

First chapter of paper contains a general survey of the commonly used minimum methods for solving boundary-value problems in statics and shows how they are related to each other and to the well-known methods of expansion of a conditioned function in a series.

The second chapter contains a description of a method ("orthogonal method") for calculating a first approximation to a solution of a partial differential equation with homogeneous boundary conditions, a method expounded in a paper published by the author in 1948 [AMR **1,** Rev. 1585]. In present paper, this method is dealt with more circumstantially, and is illustrated by new numerical examples. Finally, the accuracy of the method and the amount of work involved in numerical calculations are discussed in comparison with other similar methods.

From author's summary by J. L. Lubkin, USA

8. Ödman, S. T. A., Studies of boundary value problems. Part II. Characteristic functions of rectangular plates, *Proc. Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol., Stockholm,* no. 24, 283 pp., 1955.

Author tabulates the 36 lowest characteristic functions of rectangular plates, varying in side length ratio, for four sets of boundary conditions: (1) two opposite edges simply supported and the other edges built in; (2) two opposite edges simply supported and the other edges completely free; (3) all edges built in; and (4) all edges completely free. The solutions are exact for (1), (2), and approximate for (3), (4).

The exact solutions, previously known, are reproduced in a slightly modified analytical form for the sake of completeness. The approximate solutions are new. Each of them contains a single term consisting of the product of two normalized, explicit functions.

The problem of determining the natural vibrations of a plate built in at all edges is solved by using the "orthogonal method," described in part I (see preceding review). It is found that this method gives exactly the same results as the Ritz-Galerkin method applied to the same assumed function. Consequently, all solutions of this problem correspond to a minimum of strain energy.

The plate which is completely free at all edges is treated in a different manner. The orthogonal method is used only for determining an appropriate form of the assumed function, as well as two relations between the arguments of the two explicit func-

tions. On the other hand, the Galerkin formula is used on the two ordinary differential equations obtained from the strict boundary conditions of the problem. Finally, these strict boundary conditions are supplemented by two new, approximate conditions deduced from the complete expression for the internal work of the plate. These new conditions state that the total work done by the cross-sectional forces shall be approximately equal to zero at each edge of the plate. These conditions are sufficient for determining a first approximation.

The calculated frequency values are compared with previously published test results and with values computed by other authors.

From author's summary by J. L. Lubkin, USA

9. **Ödman, S. T. A., Studies of boundary value problems. Part III. Oblique plate in oblique co-ordinates,** *Proc. Swed. Cem. Concr. Res. Inst., Roy. Inst. Technol., Stockholm*, no. 25, 27 pp., 1955.

A recapitulation of Favre's derivation of the differential equation of an oblique plate is followed by a deduction of the strict homogeneous boundary conditions of the plate. Furthermore, it is shown that the expression for the strain energy of the plate enters as one of the components into the expression for the internal work of the plate derived from its differential equation. The latter expression is used for deducing "complementary boundary conditions," which can conveniently be employed in those cases where the assumed function cannot be caused to satisfy the strict boundary conditions of the problem. Finally, the expressions for the cross-sectional moments and cross-sectional forces are deduced in directions parallel or, alternatively, perpendicular to the edges. From author's summary by J. L. Lubkin, USA

10. **Bonder, J., Conformal mapping of the half plane into an exterior of arcs of some algebraic curves** (in Russian), *Časopis Pěst. Mat.* **1,** 4, p. 76, Feb. 1952.

In this paper an effective method is given which permits construction of functions which map uniquely and conformally the upper half plane $t = r + is$, $[s > 0]$ into a z-plane from which an arc of an algebraic curve is removed.

The cases for parabolic, elliptic, hyperbolic, and Cassini's ovaloid arcs are considered in detail.

From author's summary by R. M. Evan-Iwanowski, USA

11. **Iushkov, P. P., Improving the convergence of series obtained by a precise harmonic analysis** (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **19,** 171–178, 1954.

Author constructs a fast converging Fourier series for a continuous periodic function (with or without an analytic expression). The period is divided into twelve equal intervals and the curve approximated by six parabolic segments, each segment passing through three consecutive points of the thirteen points on the curve. The function consisting of the parabolic segments is written as the sum of two functions, one of which is defined in such a way that it makes the second function have a fast converging Fourier series. The defined function is expressed analytically and in a table in terms of finite differences on the original points. The Fourier coefficients for the second function are expressed in terms of the conventional Fourier coefficients determined by the original points. B. E. Gatewood and V. A. Valey, USA

12. **Albrecht, J., Contributions to the Runge-Kutta method** (in German), *ZAMM* **35,** 3, 100–110, Mar. 1955.

For a differential equation of order n, author exhibits the undetermined system of relations to be satisfied by the coordinates of intermediate arguments and the various weight factors of a Runge-Kutta method of integration with local truncation error of order $n + 3$ in the step size. He also considers the specializations for intermediate arguments symmetrically distributed forward and backward from the last argument. For a second-order equation free of first derivatives, a type to which any first-order equation can be transformed by differentiation, he describes a Runge-Kutta method with local truncation error of seventh order. For the Heun and Kutta methods for integration of first order, he presents simple estimates of the total truncation error.

J. H. Giese, USA

13. **Lotkin, M., On the improvement of accuracy in integration,** *Quart. appl. Math.* **13,** 1, 47–54, Apr. 1955.

Solution of differential equations by step methods can be economized by altering size of steps as integration proceeds. Different solutions based on different steps can be employed to obtain a more accurate solution. These ideas are frequently used, though mostly separately. Paper develops a scheme to incorporate both techniques in a proper manner. Some examples are given.

Y. L. Luke, USA

14. **Maximon, L. C., On the evaluation of indefinite integrals involving the special functions: Application of method,** *Quart. appl. Math.* **13,** 1, 84–93, Apr. 1955.

Results of a previous paper (see following review) are applied to associate Legendre functions, confluent hypergeometric function, and Bessel functions. Procedure is extended to evaluate integrals involving functions which are solutions of linear homogeneous differential equations of any order.

Y. L. Luke, USA

15. **Maximon, L. C., and Morgan, G. W., On the evaluation of indefinite integrals involving the special functions: Development of method,** *Quart. appl. Math.* **13,** 1, 79–83, Apr. 1955.

Solution of a general second-order linear partial differential equation in two variables by Laplace transforms is employed to evaluate in closed form a large class of integrals described in title. Legendre and Whittaker functions are presented as illustrative examples. Y. L. Luke, USA

16. **Goodman, T. R., On a function associated with modified Bessel functions,** *Cornell aero. Lab. Rep.* no. CAL-72, 8 pp., June 1955.

Function treated is $M(z) = {}_0\int^\infty e^{-z\cosh u}\sinh \nu u\, du$. Author seems unaware of previous work by reviewer ["An associated Bessel function," *J. math. Phys.* **31,** 131–138, July, 1952], where a more general class of functions is studied. Above integral arises in connection with the trajectory of a particle in the neighborhood of a thin cambered airfoil. Y. L. Luke, USA

17. **Dijkstra, E. W., and Van Wijngaarden, A., Table of Everett's interpolation coefficients,** *Math. Centrum Amsterdam, Rap.* R294, 1954, published 1955.

If the interval size of a tabulated function is the constant value h, and if the value of the function is required at $x_0 + ph$, where tabulations are given at x_0 and at $x_1 = x_0 + h$, linear interpolation would give the function f the value $f_0 + p(f_1 - f_0)$, while the Everett formula adds as corrections certain multiples of the differences of even order at x_0 and x_1. The Everett coefficients are the values of the multipliers as functions of p. This table gives the values of the coefficients for $p = 0(0.0001)1$ for differences of order 2, 4, and 6. They are given to 7 decimals.

The computations were made on the electronic computer at the Mathematical Centre of Amsterdam and reproduced by a photo-offset process. A. S. Householder, USA

18. Traenkle, C. A., Determination of the root systems of algebraic equations by affinity transforms, *Quart. appl. Math.* **13,** 1, 1–18, Apr. 1955.

An approximate method of factoring nth degree algebraic equations. The special advantages of the method are most apparent when the roots are complex.

The method is an extension of the factorization presented by S. N. Lin. It is, however, applicable with good convergence to a wider variety of cases than is the Lin method. The procedures can be carried on either by semigraphical or analytical (numerical) means.

Author claims rapid convergence when a reasonably good first approximation has been obtained. Multiple roots and near multiple roots can be handled with equal facility. An error analysis is made in which it is shown that changes in root parameters are linearly dependent on variations of the coefficients of the original equation. By this means errors of the roots due to errors of input data can be assessed. This feature should make the method as useful in problems of synthesis as the root locus method of Evans. Detail procedures for desk calculator work are presented. F. W. Niedenfuhr, USA

19. Powell, F. C., A notation for vectors and tensors, *Proc. Camb. phil. Soc.* **51,** part 3, 449–453, July 1955.

Proposed notation aims at using and extending symbols in a novel way. Brevity advantages of common three-dimensional vector notation over suffix notation is extended to vectors in spaces of other than three dimensions, and to tensors.

Reviewer's opinion is that proposed notation might possibly meet with approval by some workers in fields of relativity, advanced electricity, and magnetism, or advanced elasticity, but for the majority of engineers with interests confined to vectors in ordinary three-dimensional space, advantages of new over present familiar notation will not become sufficiently apparent to justify adopting new notation, which, for example, replaces the familiar $\mathbf{U} \times \mathbf{V}$ by $\times(\mathbf{UV})$ and is thus at variance with existing literature. G. Volkoff, Canada

20. Kron, G., Inverting a 256 × 256 matrix, *Engineering* **179,** 4650, 309–312, Mar. 1955.

Method used is one previously described by author in which the physical system or a model of it is "torn apart." Inverse is given in a new form containing fewer zeros than the conventional inverse matrix. Method is claimed to give good accuracy with less computing time than conventional methods. Reader is referred to earlier papers for details. M. V. Wilkes, England

21. Bouzitat, J., Arithmetic operations in binary notation (in French), *ONERA NT* no. 21, 1–63, 1954.

Detailed description of the basic arithmetic operations is given, including number of places required, truncation errors, etc. G. W. King, USA

22. Harmuth, H., A statistical method for the solution of the Laplace differential eqution with electronic computers (in German), *Acta Phys., Austr.* **9,** 1, 27–32, Dec. 1954.

A method of solution of Laplace and Poisson differential equations on automatic electronic computers is described. The method uses the principle of the "Galton Board," replacing the rolling spheres by electrical impulses and the nails by storage capacities. "N" dimensional solutions can be represented by "$n + 1$" dimensional boards. In order to obtain good convergence by the method, it is necessary that the field potential nowhere reaches infinity. In many cases solutions can be obtained mathematically in a simple manner by the method of the Galton Board. R. K. Neumann, USA

23. Lockenvitz, A. E., Oliphint, J. B., Wilde, W. C., and Young, J. M., Geared to compute, *Automation* **2,** 8, 37–42, Aug. 1955.

Author describes sets of noncircular gears in connection with circular gears and differential gear units which can compute the following functions: reciprocal, multiplying, exponential, logarithmic, power, roots, circular trigonometric, and combinations of these. Based on the general formulas for the pitch radii of driving and driven gear, the data for the special cases are derived. The difficulties in producing precision noncircular gears are discussed. Some misprints were noted. M. Herbeck, Germany

24. Eastern Joint Computer Conference, Proceedings, Design and application of small digital computers, held under auspices of the Assn. for Computing Machinery, Amer. Inst. of Elec. Engrs., and Inst. of Radio Engrs., Philadelphia, Pa., Dec. 8–10, 1954. Amer. Inst. Elec. Engrs., New York, 92 pp. $3.

As discussed in the opening paper of this conference, the definition of a "small" computer is quite difficult. For this conference, it appears that any digital computer costing less than about $200,000 was included.

The eighteen papers presented covered applications, equipment descriptions, and technical papers on design problems and circuit techniques. Descriptions were presented for the following commercially available computers: National Cash Register CRC 102-D, the Marchant MINIAC, the Burroughs E101, the IBM Type 650 Magnetic Drum Data-Processing Machine, the ElectroData DATATRON. Two special computers were described: the Bell Telephone Laboratories TRADIC and the Remington-Rand (ERA Division) flight plan and weather message processing computer.

The application papers covered numerical solution of differential equations, automatic computer coding, information retrieval, calculation of insurance dividends, and optical design problems. Technical papers discussed the use of plugboards in computers, storage density on magnetic drums, high-speed printer, magnetic-core and transistor circuits, and characteristics of high-speed teletype input/output equipment.

Summaries of three panel discussions are given: (1) "Small digital computers and business applications"; (2) "Redundancy checking for small digital computers"; and (3) "Small digital computers to assist large digital computers."

This group of papers provides a good over-all picture of what is happening in the "small" digital computer field. Those who are interested in, or associated with, computers will find it a welcome addition to their library. L. D. Findley, USA

25. Hunter, G. T., and Clark, G. M., Electronic data-processing machines, *Instruments & Automation* **28,** 5, 782–793, May 1955.

This article is a paper presented at the Computer Clinic, First International Automation Exposition, New York, N. Y., November 29–December 2, 1954. The various items of IBM equipment available are reviewed, from the card punch machine to the large-scale electronic data-processing machines. A brief summary of the capabilities and uses of each piece of equipment is presented. The information presented is of use to both beginners and experts in the field of data-processing equipment. L. D. Findley, USA

26. Raymond, F. H., Analog calculation: Principles and contribution to the general theory [Le calcul analogique. Principes et contribution a une théorie], Torino, Casa Editrice Libreria Rosenberg and Sellier, 1954, 134 pp. 2000 Lire.

This is an account of lectures given by the author at the

Instituto Nazionale per le Applicazioni del Calcolo in Rome, 1952. The paper deals mainly with electronic analog computers. Chap. 1 is devoted to the principles of analog computation; elementary mathematical operations and examples of simple analog computers are described. Chap. 2 refers to algebraic equations and to linear differential equations, especially to those with constant coefficients. A general treatment of electronic differential analyzers follows in chap. 3. The last chap., 4, discusses accuracy and stability of analog computers. The presentation is clear and interesting; all the various aspects of electronic analog computers are discussed. The booklet is richly equipped with photographs and diagrams of American and European computers. H. Bückner, USA

27. **Chow, V. T., The log-probability law and its engineering applications,** *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 536, 1–25, Nov. 1954.

The central limit theorem implies that observed data resulting from independent additive components are normally distributed. If the components are multiplicative rather than additive, the log-normal distribution arises. Chow shows that, for a coefficient of skew of 1.139, the log-normal distribution closely resembles the extreme-value distribution which Gumbel, Hazen, et al., developed and applied to flood and rainfall data. Using this resemblance, Chow proposes a new graphical method for fitting curves to observed extreme-value data but does not demonstrate its actual use in engineering problems. With the extension of extreme-value theory to life-testing and other industrial plant problems, additional light on theoretical likenesses to related distributions is welcome.

Reviewer found several irritating incidental errors, including the use of "standard deviation" instead of "variance" in the statement of the central limit theorem, omission of the square root sign over the right side of Equation (38) and the obvious nonsymmetry of the first row of values in Table 2 due to rounding -1.6449 to -1.64 rather than to -1.65. These were apparently slips-of-the-tongue, because the central theme of the paper is valid.

Chow's 66 references do not include Professor Gumbel's two NBS works on extreme values [Applied Mathematics Series nos. 22 and 33] or his "Minimum life in fatigue" [*J. Amer. stat. Assn.* 49, 575–597] which warns on p. 581 that the log-normal distribution does not seem legitimate for extrapolation of number of cycles to fracture in fatigue. E. C. Varnum, USA

28. **Poritsky, H., and Jerrard, R. P., Graphical field plotting methods in mechanics,** *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 47–61.

Authors show that in applied mechanics one can use graphical field-plotting methods similar to those used in electrical engineering. They show how this method can be applied to such problems as torsion of shafts of varying thickness and certain compressible flow problems, and give numerous examples. They estimate an accuracy of 1 to 2% for determining an over-all stiffness constant, but only 10 to 20% for determining maximum stress concentration and warn against expecting too much of the method. D. ter Haar, Scotland

29. **Sztompke, W., editor, Geodetical dictionary in 5 languages,** Warsaw, Panstwowe Przedsiebiorstwo Wydawnictw Kartograficznych, 1954, xvi + 525 pp. Zt 65.

Dictionary contains Polish, Russian, German, English, and French terms pertaining to astronomy, photogrammetry, lower and higher geodesy, knowledge of instruments and optics, cartography, cadastral survey, measures, mining measuring system, agricultural measuring, topography, and topographical symbols. It consists of (a) a general part comprising Polish terms in alphabetical order marked with successive numbers and their foreign equivalents arranged in five respective columns, and (b) alphabetical index of foreign words and an index of Polish synonyms. Ed.

30. **Switkowski, J., editor, Textile dictionary in 5 languages,** Warsaw, Panstwowe Wydawnictwa Techniczne, 1955, xlviii + 306 pp. Zł 71.50.

The five-language dictionary proper contains about 4000 entries arranged according to Polish terms and relating to textile raw materials and technology. It contains indexes in Russian, English, French, and German. Furthermore, it contains an introduction in Polish describing technological processes applied in the textile industry. Ed.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2, 94, 149, 186, 245, 346)

31. **Sonntag, R., Problems in technical mechanics [Aufgaben aus technischen Mechnnik],** Berlin, Springer-Verlag, 1955, x + 209 pp. DM 19.50.

Textbook was used in the author's lectures at the Technical University, Karlsruhe, and is recommended to students of engineering. Examples refer to technical practice and are presented and solved in a simple way understandable to beginner students of applied mechanics. The author, with long-time practical experience, also includes examples of great interest to professional engineers, ones involving more intricate problems and suggesting application of modern techniques, following the principles of his professor, August Föppl. The examples are selected to stimulate independent thinking and are not of the type that can be automatically solved by standard formulas. In many of them, principles and laws of d'Alembert, Coriolis, and Castigliano are used which are usually difficult to be understood correctly and applied by beginners. Also, the importance of technical mechanics for design of modern machines and mechanical tools is emphasized, and 76 pages are devoted to applied dynamics referring only to mechanical engineering. There are relatively few examples in the field of structural engineering. J. J. Polivka, USA

32. **Voronkov, I. M., A course of theoretical mechanics [Kurs teoreticheskoi mekhaniki], 5th ed.,** Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1954, 552 pp.

This is a good standard textbook on the background of classical mechanics, without great mathematical pretensions. Written for students at Russian technical schools, the work emphasizes the educational approach and abounds in numerous theoretical and practical examples. Presentation is clear and vivid.

The material, current in books of this kind, is divided into three main parts: statics, kinematics, and dynamics. The first part covers 217 pages in 10 chapters. The following 147 pages are devoted to kinematics (8 chapters) and the remainder (12 chapters) to dynamics. In this last section, reader's attention is called especially to attractive chapters on some more advanced topics, such as the principle of virtual work, d'Alembert's principle, the mechanics of a rigid body, etc. Their reading is a source of intellectual enjoyment to every engineer and physicist.

The book opens with an extensive historical and philosophical introduction, giving a critical account of the development of various branches of theoretical mechanics. At the end of the volume is a short nominal index, and the book concludes with a detailed subject index.

The work must be recommended as a fine introduction to engineering mechanics. V. Vodicka, Czechoslovakia

33. Lawden, D. F., Dynamic problems of interplanetary flight, *Aero Quart.* **6,** part 3, 165–180, Aug. 1955.

With the approach of the first unmanned flight of an earth satellite, many questions arise concerning navigation of such vehicles. Particularly pressing are those questions related to fuel conservation. Author discusses several problems which will be encountered in early interplanetary flights and the relative priorities with which problems should be treated.

The most immediate problem in trajectory dynamics is solution of optical trajectories for interplanetary or satellite orbits. To this problem author devotes majority of the paper. A general discussion of maneuvers of least fuel expenditure is followed by a mathematical development of an analogous problem, the programming of a rocket for maximum range. By the method of variation of parameters, the conditional differential equations are derived which must be solved to obtain an optimum thrust program. With the assumption of a fixed-fuel-consumption program, the equations are still sufficiently difficult to require solution by high-speed digital computers.

To illustrate the method, author obtains an analytical solution of optimum thrust programming for a rocket passing above a flat, nonrotating airless earth characterized by a constant gravitational field. The solution is shown to approach gunnery conditions for maximum range when the thrust becomes very large. As an interesting example, author shows that a range increase of perhaps 10% for the V-2 rocket might have been obtained through optimum programming of the thrust and the trajectory angle. It should be pointed out, however, that the V-2 was not mechanically amenable to such an optimal program.

W. W. Berning, USA

34. Callahan, F. P., Jr., Approximately planar rigid body motion, *J. rat. Mech. Anal.* **4,** 4, 569–578, 1955.

If a symmetrical rigid body spins at high speeds about an axis which remains close to the axis of symmetry and to some fixed direction in space, the motion is called approximately planar. Euler's equations are then approximately linear; the discussion introduces complex numbers. The following special cases are considered. Free-spinning frictionless body; free-spinning body with friction proportional to the angular velocity vector; precession; frictionless top; top with friction. Appendix gives an estimate of the error of the approximation for a free-spinning body by comparison with the exact solution.

O. Bottema, Holland

35. Froda, A., On the fundamentals of the dynamics of material points (in Rumanian, with Russian and French summaries), *Acad. Repub. pop. Române. Stud. Cerc. Mat.* **3,** 321–365, 1952.

This is the main paper in a sequence devoted to the axioms of particle mechanics. [See also *Acad. Bul. Sti. Sect. Sti. Mat. Fiz.* **3,** 157–175, 435–440, 1951; **15,** 692, 835.] The author considers the usual approach inadequate because it assumes the existence of velocity and acceleration. He proposes axioms which "lend themselves to experimental verification." He takes the displacement as continuous and subject to seven postulates of a mechanical nature and three postulates of finitude (pp. 328–331). The author shows familiarity with much of the classical literature on the foundations of mechanics, and this work appears to be a serious and competent effort to make use of the theory of real functions in mechanics. The reviewer's knowledge of Rumanian is not sufficient to understand much of what the author writes, and he regrets the author has not chosen a language accessible to a greater proportion of specialists in mechanics. Essential to the author's treatment is the notion of "realizable" motion, but the reviewer cannot understand its definition as "a real motion or the limit of a sequence of real motions in which the passive resistances approach zero" (pp. 322–323), since "passive resistance" is not defined. The author's postulates apply only to realizable motions. He proves a number of theorems regarding motions satisfying his axioms: for example, velocity exists and is of bounded variation, mean acceleration is bounded, the upper and lower derivatives of velocity exist. He characterizes the possible discontinuity in the acceleration. This study is of interest in that the mechanics of impacts is automatically included without any special distinction. Nevertheless its emphasis on the type of analysis found in works on functions of a real variable may make it seem unnatural and ugly to some of those who would otherwise be interested in its results. C. Truesdell, USA

36. Poschl, Th., Note on impact problems of connected systems according to the Lagrange system (in German), *Öst. Ing.-Arch.* **9,** 2/3, 216–217, 1955.

Impact problems occurring with linkages are solved in most textbooks by means of the "synthetic" method, according to which each member is separately studied with its link and guiding forces, these being afterwards eliminated again in order to obtain the motion after the impact. This detour is avoided by using Lagrange's method. Finally, simple examples are given.

From author's summary

37. Potter, J. L., Murphree, W. D., and Shapiro, N. M., Normal force and center of pressure on right circular cylinders, *J. aero. Sci.* **22,** 3, 214–215, Mar. 1955.

Note in Readers' Forum.

38. Arzhaníkh, I. S., On the equations of rotation of a heavy rigid body around a fixed point (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **97,** 3, 403–406, July 1954.

Author shows that the motion of a heavy rigid body about a fixed point O can be interpreted (1) by the motion of a particle on the ellipsoid of inertia of this body at O, the motion taking place under the action of certain potential and gyroscopic forces, and (2) by the motion of an electrified particle under the action of a plane electric field and a perpendicular magnetic field. In this last case the motion takes place in a plane. Making use of these two interpretations and of the results of an earlier paper [AMR **8,** Rev. 1895], author claims to have shown the existence of a new linear integral different from the integral of angular momentum about the vertical through O. E. Leimanis, Canada

39. Green, A. P., Friction between unlubricated metals: a theoretical analysis of the junction model, *Proc. roy. Soc. Lond.* (*A*) **228,** 1173, 191–204, Feb. 1955.

Following Bowden and Tabor [AMR **4,** Rev. 4673], the coefficient of friction μ is defined by $\mu = s_m/p_m$, where s_m is the mean shear stress and p_m is the mean pressure over the area of contact. Treating the stress and pressure at any time as the mean effect of a large number of junctions formed by the contacting sliding bodies, it can be evaluated by the mean effect in the life cycle of a single junction. Experiments with Plasticine models are described. The Plasticine experiments show the stresses and pressure when junctions are formed, enlarged, and break. The theory expressed here overcomes the difficulties experienced by McFarlane and Tabor [title source, *A* **(202),** p. 244, 1950] in explaining how the average values s_m and p_m are determined. The effects of ductility and hardness in junction history are discussed and

mechanisms are suggested to explain the high value of μ (and seizure) in vacuum (one possible mechanism is that junctions grow so rapidly that the area of contact becomes too large for the shearing force to overcome). E. Koenigsberg, USA

40. Kuhlenkamp, A., Linkage layouts by mathematical analysis, *Prod. Engng.* **26,** 8, 165–170, Aug. 1955.

Paper is concerned with kinematic synthesis of linkages on basis of Grübler's relations between number of links, joints, and degrees of freedom as developed by Kraus ["Grundlagen der Getriebeleure," Hanover, 1949]. Approach is typical of the Brunswick German school of Altmann [Kutzbach, *ZVDI* **77,** 1168, 1933; *ZVDI* **81,** 890, 1937; Altmann, *ZVDI* **92,** 902, 1950; *ZVDI* **93,** 205, 1951, etc.] Geometrical problems are not considered at all, but more than twenty illustrative examples are given. German literature in this field has rarely been abstracted in AMR. E. M'Ewen, England

41. Tolle, O., On the application of "the plane of relative normal acceleration" in dynamics of linkages (Inertia pole of a disk in plane motion and center of curvature of coupled curves) (in German), *Ing.-Arch.* **22,** 227–236, 1954.

The force on a moving plane body may be determined by the use of the angular velocity and acceleration of the body, its mass and moment of inertia, and the locations of the center of gravity and center of oscillation. A graphical construction which made use of the "plane of relative normal acceleration" was discussed by M. Tolle [*ZVDI* **76,** 799–800, 1932] and others. The present paper summarizes the construction and shows several applications. In particular, the radius of curvature of the paths of selected points of the body may be determined. M. Goldberg, USA

42. Matthieu, P., On the calculation of hyperboloid gear systems (in German), *Ing.-Arch.* **21,** 1, 55–62, 1953.

The general solution of the problem of hyperboloid gear systems consists of the following: A gear surface $f_2(x_2,y_2,z_2) = 0$ in the hyperboloid surface is given and an equation $f_1(x_1,y_1,z_1) = 0$ of the corresponding conjugate surface is to be found. This problem is solved analytically by author for the special case when the axes 0_1 and 0_2 are perpendicular, and simple solutions are given by which it is possible to define $f_1 = 0$ when $f_2 = 0$ is given.

As a constant axis system xyz, author considers a system whose axis x coincides with the axis 0_1 and axis y is parallel to 0_2. Also the moving systems $(x_2y_2z_2)$ and $(x_1y_1z_1)$ are considered to be joined with the moving surfaces $f_2 = 0$ and $f_1 = 0$. If we consider the relative moment of the surface $f_1 = 0$ to the surface $f_2 = 0$, we have the equations $f_2(x_2,y_2,z_2) = 0$, $f_1(x_1,y_1,z_1) = 0$, $[df_1(x_1,y_1,z_1,t)]/dt = 0$ by which we shall find the equation of the conjugate surface $f_1 = 0$. (x_2,y_2,z_2) and (x_1,y_1,z_1) are connected by the formulas for transformation of axes.

For the simplification of the solution, polar coordinates are introduced so that the equation of surface $f_2 = 0$ will be $\varphi_2 = \varphi_2(r_2,\theta_2)$. To this corresponds a system of equations whose second parts contain r_2, θ_2, φ_2, and t, and by elimination equation $\varphi_1 = \varphi_1(r_1, \theta_1)$ will be found.

The parametrical form of the above equations permits the arithmetical definition of points $Q(r_1{}^*, \theta_1{}^*, \varphi_1{}^*)$ of surface $\varphi_1 = \Phi_1(r_1, \theta_1)$. Thus author suggests a practical method of finding surface $\varphi_1 = 0$. C. P. Papaioannou, Greece

43. Matthieu, P., Calculation of hypoid gears (in German), *Ing. Arch.* **21,** 287–291, 1953.

In a previous paper, "Über die Berechnung der Hypoidgetriebe," the author gave an analytical solution, along with a practical arithmetic procedure, for defining the correspondence of a conjugate surface to a given gear surface of a hyperboloid gear system when the axes 0_1 and 0_2 are perpendicular. In the present paper, he extends the previous work to the general case when 0_1 and 0_2 form an angle ϵ. The process followed by the author is the same as that used for the perpendicular-axis solution. C. P. Papaioannou, Greece

44. Cook, F. E., and Milwitzky, B., Effect of interaction on landing-gear behavior and dynamic loads in a flexible airplane structure, *NACA TN* 3467, 75 pp., Aug. 1955.

The effects of interaction between a landing gear and a flexible airplane structure on the behavior of the landing gear and the loads in the structure have been studied by treating the equations of motion of the airplane and the landing gear as a coupled system. The landing gear is considered to have nonlinear characteristics typical of conventional gears, namely, velocity-squared damping, polytropic air-compression springing, and exponential tire force-deflection characteristics. For the case where only two modes of the structure are considered, an equivalent three-mass system is derived for representing the airplane and landing-gear combination, which may be used to simulate the effects of structural flexibility in jig drop tests of landing gears.

As examples to illustrate the effects of interaction, numerical calculations, based on the structural properties of two large airplanes having considerably different mass and flexibility characteristics, are presented. For the particular cases considered, it was found that the effects of interaction can result in appreciable reduction in the magnitude of the landing-gear force, particularly when the flexibility of the airplane structure is large and the natural frequency is small. Thus, neglect of interaction effects, that is, the use of the landing-gear forcing functions for a rigid airplane, in a dynamic analysis of a flexible airplane can lead to the calculation of excessive loads in the airplane structure.

In the case of one of the airplanes considered, the structural loads calculated from the interaction solutions are greater than those for a completely rigid airplane treatment (rigid structure subjected to a rigid-body forcing function) because the effects of dynamic magnification more than overcome the reduction in landing-gear force due to interaction. In the case of the second airplane, because of the relatively large natural period of the structure in comparison with the duration of the impact pulse, the dynamic magnification factor is appreciably less than unity. This effect, coupled with the reductions in landing-gear force due to interaction, results in structural loads that are less than those for a rigid airplane. From authors' summary

Servomechanisms, Governors, Gyroscopics

(See also Rev. 56)

45. Ahrendt, W. R., Servomechanism practice, New York, McGraw-Hill Book Co., Inc., 1954, vii + 349 pp. $7.

Stated purpose of text is to present to those readers with reasonable grounding in servomechanism theory some practical aspects of application of this theory in selection of physical hardware required to evolve a suitable servomechanism.

Accordingly, first chapter describes the basic elements and characteristics of a simple servomechanism, and next 12 chapters present a somewhat detailed description of the properties and peculiarities of the following common components: Potentiometers, synchros, and related error detectors; double-speed synchronizing networks; demodulators and modulators; networks; electronic amplifiers; rate generators; servomotors; friction dampers; magnetic amplifiers; rotating amplifiers; and hydraulic systems. The succeeding chapters present some remarks on design philosophies, manufacture, assembly, adjustment, and testing of servo-

mechanisms. The design processes involved in the evaluation of a "typical servomechanism" are illustrated.

The problems bearing on the material of each chapter are generally nonnumerical in nature and are designed to emphasize, somewhat closely, the points made in each case.

In addition to the Appendix, which is a brief review of simple linear servo theory, and some useful tables and charts, a glossary of terms is included, which has the advantage of precisely defining some of the terminology which is often vague or confused in the literature.

The material is well and logically presented, although some additional very common components, such as accelerometers and gyroscopic elements, could well have been included. The greatest value of this book is in pointing out to the inexperienced student the pitfalls and the departures from linear and idealized servo theory inherent in the use of practical servo components and assemblies. It will also serve the student as a useful guide in attacking and solving some of the problems of servomechanism design with which he may be confronted. It is reviewer's opinion that there is a definite need for such a text.

L. Becker, USA

46. Tuzov, A. P., Stability questions for a certain regulating system (in Russian), *Vestnik Leningrad. Univ.* **1955,** no. 2, 43–70, 1955.

In several articles, Erugin [*Promish. mat. i mehan.* **14**, no. 5, no. 6, 1950; **16**, no. 5, 1952] invesigated the stability in the whole plane of a system

$$\dot{x} = a_{11}x + a_{12}y + f(x), \quad \dot{y} = a_{21}x + a_{22}y \qquad [1]$$

under the assumptions for $x \neq 0$

$$(a_{11} + a_{22})x^2 + xf(x) < 0 \qquad [2]$$

$$(a_{11}\,a_{22} - a_{21}\,a_{12})\,x^2 + a_{22}xf(x) > 0$$

The present paper deals with the same sort of question for a system

$$\begin{aligned} \dot{x} &= a_{11}x + a_{12}y + a_{13}z + f(x) \\ \dot{y} &= a_{21}x + a_{22}y + a_{23}z \\ \dot{z} &= a_{31}x + a_{32}y + a_{33}z \end{aligned} \qquad [3]$$

where $f(x)$ satisfies conditions of similar type to [2]. Author arrives at his highly complicated results (local asymptotic stability, stability in the large, stability as a whole) by a tireless consideration of particular cases, imposing, also, very often highly special conditions. One of the simplest is, for example, $\lambda x^2 < x\,f(x) < \mu x^2$. It would be hopeless to give any sort of details.

S. Lefschetz, Mexico

47. Dörr, J., Function theoretical methods for transfer and control problems (in German), *ZAMM* **34,** 8/9, 287–289, Aug./Sept. 1954.

Transfer functions for low-pass filters are expressed in realizable form by means of Cauchy's integral theorem. Explicit results are given in terms of Chebíshev polynomials.

W. A. Mersman, USA

48. Gibson, J. E., Fourteen ways to generate control functions mechanically, *Control Engineering* **2,** 5, 65–69, May 1955.

Author lists all possible, significant, linear, damper spring L networks with two or three elements and all four-element networks with two elements in each arm. Included with each network is the transfer function in terms of parameters and the asymptotic gain curve.

J. G. Truxal, USA

49. Fenemore, R. W., and Borley, C. R., Automatic control of machine tools, *Research, Lond.* **8,** 9, 351–356, Sept. 1955.

The possibilities of employing numerical control systems for machine tools are discussed. Accurate measuring systems which are used with machine tool slides and tables, as well as systems that process numerical input data and issue instructions to the machine tool coordinate positioning system, are being evolved at present. The article also indicates potential lines of development—for example, completely automatic contour and profile milling machines could be used in the manufacture of "masters" and prototype equipment.

From authors' summary

50. Automatic control terminology, Prepared by the Terminology Committee of the Instruments and Regulators Division of ASME, 23 pp., 1954.

51. Linnik, Yu. V., and Novoselov, V. S., Random disturbances of the regular precession of a gyroscope (in Russian), *Prikl. Mat. Mekh.* **17,** 3, 361–368, May/June 1953.

A system of differential equations

$$dx_i/dt = X_i[x_j,\, A_k(t),t] + S_i[x_j,A_k(t),t],\ i,j = 1,\ldots,n$$

is considered, where the function $A_k(t) = a_k(t) + b_k/(t)$, $k = 1,\ldots,l$, describes the lth random process; a_k is here "the mathematical expectance" (hope).

The solution $x(t) = \{x_i(t)\}$ is also the nth random process. Thus the problem is reduced to an examination of the extent of the probability that the solution's disturbance $x(t)$ tends toward the solution $y_i(t)$, appropriate to the conditions: $x_i^0 = y_i^0$, $A_k = a_k$, $S_i = 0$, where y_i^0 is the "expectance" of x_i^0.

Assuming that the values $\max|b_k/a_k|$, $\max|(x_i - y_i)/y_i|$, in a finite time interval, have small dispersions, the functions S_i present a set of random surfaces. Since a set of equations may be linearized, the solution is given in matrix form.

To establish the probability problems' characteristics, one examines the correlation matrix and the correlation function. In certain cases the correlation matrix cannot be obtained theoretically (e.g., the noise in radiotechnics).

The derived relations are applied to estimating the probability of the disturbance of the regular precession of a gyroscope, assuming that the correlation matrix is known (or experimentally determined).

A brief bibliography is entirely in Russian. [See AMR **6,** Rev. 3625.]

D. Rašković, Yugoslavia

Vibrations, Balancing

(See also Revs. 48, 85, 179, 246, 248, 312, 323, 338)

52. Bulgakov, B. V., Oscillations [Kolebaniya], Moscow, Gos. Izdat. Tekh.-Teor. Lit., 1954, 891 pp. (1 plate). 29.40 rubles.

This very large volume—nearly 900 pages—is a posthumous work by the man who, for a number of years, occupied the chair of mathematics and mechanics of the University of Moscow. The first two of the three parts which comprise it appeared as a first volume of this contemplated work in 1949. The third part, left uncompleted at the author's death in 1952, was prepared for publication by J. N. Roitenberg.

The first part (first three chapters) is strictly preparatory and covers material amply expounded in the literature: matrixes (97 pages); operator calculus (55 pages); equations of dynamics (33 pages). The subject of oscillations properly begins with the fourth chapter (p. 203). The book is destined above all for applied mathematicians; it will only give moderate satisfaction to

pure mathematicians. It is replete with engineering problems very well and very fully discussed. Part II deals with systems of one degree of freedom, and part III with systems of a finite number of degrees of freedom. Not content to plant directly before the reader the appropriate differential equations of the oscillations, author always indicates their derivation and generally starts from energetic considerations. The mathematical treatment is always dealt with carefully and with due respect.

A brief description of the various chapters from the fourth on (first of Part II) follows.

Part II. Systems of one degree of freedom. Chap. 4: Equations of motion, canonical and linear systems. Linear systems with constant coefficients; oscillatory systems as linear filters; automatic regulation; general solution; stability of osillations. Linear systems with a lag (difference-differential equations with constant coefficients).

Chap. 5: Self-oscillations of nonlinear systems. Conservative systems. Dissipative systems. Self-oscillatory systems: clocks, vacuum tubes, steam engine. Method of small parameters of Poincaré. Quasi-linear systems, their approximations. Application to vacuum tubes and steam engines. Averaging method.

Chap. 6: Forced oscillations. Approximations. Stationary systems with same period as forced oscillation. Systems with nonlinear forced oscillations, also with viscous friction.

Part III. Systems of a finite number of degrees of freedom. Chap. 7: Small oscillations around a given state. Variation equations. Reduction to the first order. Stability. Influence of variable parameters. Application to steam engine with regulator. Small oscillations of a natural system around a steady state.

Chap. 8: Linear system with constant coefficients, their oscillations, self-oscillations, and stability. Chap. 9: Passive systems (i.e., without exterior source of energy). Linear conservative systems with constant coefficients. Synthesis of bipolar and quadripolar systems.

Chap. 10: Linear regulated systems, with application to gyroscopic stabilization and to ships with automatically regulated rudder. Nyquist criterion. Chap. 11: Linear systems with periodic coefficients. Chap. 12: Nonlinear systems. Method of Poincaré (small coefficients). Chap. 13: Averaging method.

Appendix: On motions with forced oscillations of high frequency. (Translation of a paper by the author which appeared in the 1940 volume of *Compositio matematica*).

The volume concludes with a rather complete index and an ample bibliography. S. Lefschetz, México

53. Heinrich, G., Energy transport in elastic media (in German), *Öst. Ing.-Arch.* **9**, 2/3, 148–156, 1955.

An energy flow velocity is introduced that can be assigned to the vector of energy transport. Energy transport, as well as the energy flow velocity, are investigated in greater detail for the special cases of longitudinal bar vibrations, transversal vibrations of a chord, and of bending vibrations of a bar.

From author's summary by H. Deresiewicz, USA

54. Popov, E. P., Approximate calculation of self-excited and forced vibrations in nonlinear systems of higher order on the basis of the harmonic linearization of nonlinearity (in Russian), *Izv. Akad. Nauk Otd. Tekh. Nauk* no. 5, 3–38, May 1954.

The well-known approximate method of harmonic linearization of nonlinearity (Krylov and Bogolyubov), based on the estimation of the first harmonic of the nonlinear function with sinusoidal argument, is applied to equations occurring in investigations of complicated closed nonlinear automatic control systems.

As this method reduces the given system to an equivalent linear system, it is possible to set up the characteristic equation of the linearized system. Now, using the analytical expression of Michaylov's criterion, the regions of stability and the influence of parameters of the system upon the amplitude and frequency of periodic solution may be investigated. For the same purpose, a graphical solution is described.

Author neglects the influence of higher harmonics of the argument. Forced oscillations are examined for the case when the right-hand function is sinusoidal.

Paper contains a few fully solved examples illustrating the application of the method.

K. Julis, Czechoslovakia

55. Minorsky, N., On the stroboscopic method, "Studies in mathematics and mechanics" (Presented to R. von Mises by Friends, Colleagues, and Pupils), Academic Press, Inc., New York, 192–199, 1954.

Paper presents a method for finding the periodic solutions of nonlinear differential equations. The intuitive idea on which the method is based is the following: A mechanical system in periodic motion, illuminated stroboscopically, would, as a rule, exhibit an apparent motion different from its actual. If illuminated in particular at time intervals equal to its period, it would appear to stand still. This idea is formulated mathematically for the case of slightly nonlinear second-order differential equations, with or without forcing term, whose periodic solutions are of known period. The method is illustrated with three examples.

Reviewer has not found the mathematical treatment altogether convincing, nor was it obvious to him that the same conclusions could not be reached by conventional reasoning as efficiently as by the method proposed in the paper. R. Drenick, USA

56. Mitropol'skiĭ, Y. A., On the effect on a nonlinear oscillator of a "sinusoidal" force with modulated frequency (in Russian), *Ukrain. mat. Zh.* **2**, 6, 442–447, 1954.

This is a continuation of two earlier papers [*Prikl. Mat. Mekh.* **14**, no. 2, 1950; *Inzhener. Sbornik*, **15**, 1953]. Here the author discusses the solutions of

$$\ddot{x} + \omega^2 x = \epsilon f(x,\dot{x}) + E \sin \theta$$

$$\dot{\theta} = \nu(t) = \nu_0 + \Delta\nu_0 \cos \Omega t$$

The methods of the first quoted paper (à la Krylov-Bogolyubov) are applicable for $\Delta\ \nu_0$ or Ω small relative to ν_0. Two special cases are discussed mainly by graphical methods.

S. Lefschetz, Mexico

57. Dubosin, G. N., On integration of a system of linear equations of the second order by the method of A. M. Lyapunov (in Russian), *Moskov. Gos. Univ. Trudy Gos. Astr. Inst.* **24**, 109–121, 1954.

Paper purports to solve

$$\ddot{x} = Q(t)\dot{x} + P(t)\,x \qquad [1]$$

(x an n vector, P and Q matrixes) as follows:

Replace [1] by

$$\ddot{x} = \bar{Q}\dot{x} + \bar{P}x + \epsilon(Q - \bar{Q})\dot{x} + (P - \bar{P})x \qquad [2]$$

Solve [2] by series

$$x = x^{(0)} + \epsilon x^{(1)} \ldots . \qquad [3]$$

absolutely convergent in some interval around $\epsilon = 0$; then make $\epsilon = 1$, thus obtaining a solution of [1] for which many formulas are developed. Reviewer fails to see that [3] converges for $\epsilon = 1$. S. Lefschetz, Mexico

58. Boyce, W. E., Di Prima, R. O., and Handelman, G. H., Vibrations of rotating beams of constant section, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 165–173.

Paper is concerned with the problem of determining the natural frequencies of a beam rotating about an axis at one end and vibrating transversely to the plane of rotation. Boundary conditions at the restrained end vary from clamped to pinned.

Procedure of analysis is based on the variational method which, in addition to meeting the requirements of the differential equation, must satisfy the so-called natural boundary conditions. Major portion of the paper deals with the role played by the natural boundary conditions in establishing the upper and lower bounds to the natural frequencies of the system. The procedure established, which is applicable to higher frequencies as well as the fundamental, incorporates the Rayleigh-Ritz method for the upper bounds and the Southwell technique for the lower bounds. Numerical results for the upper and lower bounds for the first two natural frequencies of a uniform beam are tabulated for several end conditions and a range of rotational speed. A recent report by T. Yutema ["Simplified procedure and charts for the rapid estimation of bending frequencies of rotating beams," *NACA TN* 3459, June 1955] treats a similar problem.

W. T. Thomson, USA

59. Veletsos, A. S., and Newmark, N. M., A simple approximation for the fundamental frequencies of two-span and three-span continuous beams, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 143–146.

The procedure is based upon an approximation formula for the fundamental frequency of a partly restrained bar published previously by the authors. The formula can be applied to a continuous beam by isolating from it one of the spans and introducing the restraints existing at the ends of that span. It is with these restraints that the present paper is concerned.

An approximation formula for the two-span beam and a method of successive approximation for the three-span beam are presented. Numerical examples are worked out and maximum errors are discussed. H. Parkus, Austria

60. Veletsos, A. S., and Newmark, N. M., Determination of the natural frequencies of continuous beams on flexible supports, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 147–155.

Holzer's well-known method (the name is in reviewer's opinion, not quite justified, since the basic idea of the method was first conceived by Guembel in 1912) was originally devised for torsional vibrations. Later, many modifications and extensions to other types of vibrations have been suggested. This paper presents an extension of the method to undamped flexural vibrations of continuous beams on elastic supports, mass and rigidity of the beam being piecewise constant. The effects of concentrated masses can also be taken into account.

Several elastic parameters are used in the computations. They have been tabulated as functions of a frequency parameter by the first of the two authors in his doctoral dissertation published as a *Bulletin* of the University of Illinois Engineering Experiment Station. H. Parkus, Austria

61. Imachi, I., On the lateral mass-impact applied to a long uniform bar with two flexual freedoms—bending and shearing, *Mem. Fac. Engng. Univ. Nagoya* **2,** 1, 1–28, Apr. 1950.

The propriety of reviewing a paper almost six years after its original publication, in a journal such as these REVIEWS, may be seriously questioned; however, the reviewer believes this paper warrants such action. Paper presents an analysis of the Timoshenko equation of flexural vibration of beams; its importance, however, is due largely, in reviewer's opinion, to the fact that it appears to be an analysis independent of the work of Flügge, Prescott, and others. The results presented, therefore, are rather well-known today, except that some effects of damping are considered. As with most workers, author discusses only lower branch of the dispersion curve and treats only the case of infinitely long beams. Analytical method is based on superposition of normal modes. Analysis considers internal damping as proportional to the strain velocity and external damping as proportional to the displacement velocity; the effects of these damping factors on the arrival times of waves are discussed. Some experimental results are described, but these appear to be inferior to those published more recently.

Paper should be interesting to workers in this field for its historical position, if for no other reason. H. N. Abramson, USA

62. Lo, H., and Bollard, R. J. H., Coupled bending torsion vibration of a trapezoidal box beam with warping restraint, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 157–163.

Paper treats the vibration of a thin-walled tube the cross section of which has one axis of symmetry. The tube is supported as a cantilever with a concentrated mass attached at a distance e/L from fixed wall. Motion of cross section is considered to be the sum of rigid body rotation, rigid body bending displacement perpendicular to axis of symmetry, and warping displacement along the longitudinal axis. The bending and torsion are coupled by the warping displacement. Numerical results are presented and plotted for the percentage of increase in the fundamental frequency due to warping restraint. W. T. Thomson, USA

63. Lisowki, A., Vibrations and stability of cylindrical plates (in Polish), *Inżyn. Budown* no. 1, 29–32, Jan. 1955.

Experimental work has been conducted on determination of the forms of deformation of cylindrical plates under critical loads, and deflections in vibratory motion as fundamental frequencies. In both cases, wave-form deformations have been obtained; this fact permits extending the previously made observation as to the similarity of the form of deformations under these two conditions in rods, arcs, and plates to cylindrical plates (cf. A. Sommerfeld, *ZVDI*, 1905). The knowledge of deformations (wave length) permits calculation of critical loads or frequencies, respectively. Author claims that experimental results agree well with theoretical computations; unfortunately, no comparative results are quoted. R. M. Evan-Iwanowski, USA

64. Hoppmann, W. H., II, and Greenspon, J., An experimental device for obtaining elastic rotational constraint on boundary of a plate, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 187–191.

Authors propose a notched boundary to simulate the rotational constraint along an edge in testing the vibration frequency of plates, particularly in the limiting case of zero rotational constraint, i.e., a simply supported plate. Authors conclude that the simply supported plate is simulated with sufficient accuracy by a notch over three quarters of the plate thickness. Reviewer believes this approach to be a good workable one, but suggests that the authors' quantitative conclusions not be applied to plates of greatly different dimensions without an experimental study, similar in scope to that undertaken by the authors, to determine the variation of the frequency with depth of notch.

E. J. McBride, USA

65. Galletly, G. D., On the in-vacuo vibrations of simply supported, ring-stiffened cylindrical shells, *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 225–231.

Vibration frequencies of a simply supported thin cylinder reinforced with equally spaced rings are obtained analytically. Energy approach is used in conjunction with an approximate assumed deflection function which allows inter-ring deformation of cylinder. Results are obtained for various ring sizes and for several numbers of circumferential waves. Comparisons are made with results of more approximate methods; agreement is within 10%.

J. M. Hedgepeth, USA

66. Tagliacosso, C., On the vibration of elastic solids under movable constraints (in Italian), *G. Gen. civ.* **93,** 2, 87–107, Feb. 1955.

Author considers an elastic body, bounded partly by movable constraints, otherwise by fixed constraints. Where the constraints are movable, the displacements are known as functions of the time. Author proves the uniqueness of solution for the equations of displacements; a minimum theorem like Menabrea's theorem; and the theorem

$$\delta \int_{t_1}^{t_2} (T - \Phi - \theta)\, dt = 0$$

where T is the kinetic energy of the body, Φ the elastical energy functions of the stresses, θ the work of reactions of constraints; the variation of the displacements are zero at the instants t_1, t_2.

D. Graffi, Italy

67. Duncan, J. P., Geared marine turbine drives. Torsional vibration characteristics examined by direct electrical analogy, *Engineering* **179,** 4653, 404–409, Apr. 1955.

Author considers particular example, two-cylinder double-reduction steam turbine driving propeller, developing 7300 bhp at 100 rpm. This is reduced to equivalent one-speed system with two branches. Expressions developed for propeller forcing torque (proportional to square of angular speed) and damping torque (terms in displacement and velocity) and differential equations for system are written down. Analogous electrical circuit is developed and solutions obtained for differential equations, giving resonant frequencies of the system. Finally, electrical system was built and used to obtain frequency response curves for the three shafts of turbine set on screen of cathode-ray oscilloscope. Good agreement is shown between frequency-response curves from use of Holzer method on original system, solution of analogous electrical circuit, and measurement from electrical system. Paper is very useful in giving numerical values for quantities involved.

E. Giffen, England

68. Tsobkallo, S. O., and Chelnokov, V. A., New method for the determination of true damping of oscillations in metals (in Russian), *Zh. tekh. Fiz.* **24,** 3, 499–510, Mar. 1954.

Authors describe experimental method, in which number of cycles N is counted by a binary electronic computer between two given values of the amplitude, x_0 and x_N, in free bending vibrations. Logarithmic decrement is found from formula $\delta = (\ln x_0 - \ln x_N)/N$. Ratio x_0/x_N may be chosen comparatively close to unity without great loss of accuracy.

Experimentally found damping is a mean value for cross section. Authors show how to compute true damping, i.e., damping at a fixed stress level, from this mean value for rectangular and cylindrical specimens. Method is illustrated by experimental results for two different kinds of steel, with mean value and true damping as functions of stress. F. Niordson, Sweden

69. Chatterjee, G. P., A simple method of measuring vibration damping capacities of metals and alloys, *J. Instn. Engrs., India* **35,** 1, 30–37, Sept. 1954.

Low-carbon steel specimens were subjected to a forced amplitude of vibration to known stress (about 18,000 psi) levels. Internal friction (specific damping capacity) was determined by measuring the rate of temperature rise over about one minute of time by means of thermocouples. Temperature changes of about 0.5 C were observed which had constant slope over this period of time. Equations relating the specific damping capacity to the conditions of the experiment and properties of the materials are given. I. Vigness, USA

Wave Motion in Solids, Impact

(See also Revs. 36, 44, 61, 85, 126, 132, 160)

70. Smith, E. A. L., Impact and longitudinal wave transmission, *Trans. ASME* **77,** 6, 963–973, Aug. 1955.

The necessary formulas for a numerical method of calculation are derived without the use of calculus or other advanced mathematics; an illustrative problem is solved in complete detail. Eight different types of impact are discussed; methods are given for taking account of friction, damping, coefficient of restitution, plastic flow, and gravity. Branched systems are discussed briefly. Methods are given for checking the calculated results.

From author's summary by H. N. Abramson, USA

71. Sato, Y., Analysis of dispersed surface waves by means of Fourier transform. I, *Bull. Earthq. Res. Inst., Tokyo Univ.* **33,** part I, 33–50, Mar. 1955.

Author shows how the method of Fourier transforms can be used to find the dispersion formula and the spectrum of vibration near the origin of seismic disturbance. It is observed that the dispersion curves obtained by this method agree well with those arrived at by the usual method of measuring the intervals from crest to crest. The method is applied to the analysis made by F. Kishinouye of the practical record of an explosion at Lake Haruna [title source, **21,** p. 298, 1943]. From the dispersion curve obtained by the method of this paper, thickness of the ice plate has been calculated and has been found to be in good agreement with the value obtained by Kishinouye from direct measurement. A. M. Sen Gupta, India

Elasticity Theory

(See also Revs. 53, 87, 89, 90, 92, 93, 101, 106, 115, 137, 138, 139, 140, 162, 165, 291, 323)

72. Adkins, J. E., Some general results in the theory of large elastic deformations, *Proc. roy. Soc. Lond.* (*A*) **231,** 1184, 75–90, July 1955.

Author considers general type of cylindrically symmetrical deformation

$$\rho = \rho(r),\ \psi = \varphi(r) + a\theta + bz,\ \zeta = w(r) + c\theta + dz$$

where (r,θ,z), (ρ,ψ,ζ) are cylindrical polar coordinates in the undeformed and deformed bodies respectively, and a, b, c, d are constants. This includes as special cases the problem of flexure; the inflation, extension, and torsion of a cylindrical tube, and the shear of a cylindrical annulus. A general strain-energy function is used for both compressible and incompressible bodies possessing a suitable type of curvilinear aeolotropy, and the strain-energy is regarded as a function of the parameters defining the deformation. Results are also valid for isotropic bodies. General

formulas are given for resultant forces and couples required to maintain the deformation. Corresponding types of deformation for a cuboid are considered.

Paper closes with a generalized shear problem, in which each point of elastic body moves parallel to an axis through distance which is a general function of position in a plane normal to that axis. A. E. Green, England

73. Cotter, B. A., and Rivlin, R. S., Tensors associated with time-dependent stress, *Quart. appl. Math.* **13,** 2, 177–182, July 1955.

It is assumed that six functional relations exist between the components of stress and their first m material time derivatives and the gradients of displacement, velocity, acceleration, second acceleration,. . ., $(n - 1)$th acceleration. It is shown that these relations may then be expressed as relations between the components of $m + n + 2$ symmetric tensors if $n > m$, and $2m + 2$ symmetric tensors if $m > n$. Expressions for these tensors are obtained. From authors' summary by S. F. Borg, USA

74. Lodge, A. S., The transformation to isotropic form of the equilibrium equations for a class of anisotropic elastic solids, *Quart. J. Mech. appl. Math.* **8,** part 2, 211–225, June 1955.

A general investigation of the problem of whether the fundamental equations of an anisotropic elastic body may be reduced to the equations of an isotropic body. This is proved in several cases by a linear transformation. There exist conditions for the several elastic constants of the anisotropic body. Three special cases of anisotropy are treated in detail.

F. Schultz-Grunow, Germany

75. Signorini, A., An explicit analysis of the mean properties of stress which are common to all continuous systems (in Italian), "Studies in mathematics and mechanics" (Presented to R. von Mises by Friends, Colleagues, and Pupils), Academic Press, Inc., New York, 274-277, 1954.

Author considers a cylindrical solid, however solicited, without special hypotheses upon the constitution and physical state, and obtains a simple, geometrically elegant, necessary condition to impose to the total solicitation, so that, for all elements of all normal sections, the greatness of the specific normal stress is lower than a fixed security bound. Proof is based upon a general inequality which author obtained earlier [*Ann. Scu. norm. sup. Pisa,* 1933] and in which he opposed the unknown stress components to the means, over the body, of them and of the products of the same components by the coordinates: these means may be calculated from applied loads. R. Nardini, Italy

76. Sonntag, R., L. Föppl's method of conformal mapping of two-dimensional stresses applied to the problem of parallel strips (in German), *ZAMM* **34,** 435–438, 1954.

Following L. Föppl [title source, **11,** 81–92, 1931], author uses conformal mapping to deduce L. N. G. Filon's [*Phil. Trans. roy. Soc. Lond.* (A) **201,** 63–155, 1903, p. 106] solution for the infinite strip, subject to two concentrated edge forces at opposite points of the boundary, from the known solution for the circle under concentrated forces. The obtained solution contains a Fourier integral, which converges better and hence is more suitable for computation than Filon's. The case of bending of beams by concentrated load is also deduced from this solution.

J. R. M. Radok, Australia

77. Symposium on thermal fracture, compiled by W. D. Kingery, *J. Amer. ceram. Soc.* **38,** 1, 1–54, Jan. 1955.

The eight papers include a very comprehensive treatment of the problem. Titles and authors are: "Recommended letter symbols for thermal stress analysis" compiled by W. D. Kingery; "Factors affecting thermal stress resistance of ceramic materials" by W. D. Kingery; "Thermal shock testing" by W. R. Buessem; "Theory of thermal shock resistance of brittle materials based on Weibull's statistical theory of strength" by S. S. Manson and R. W. Smith; "Thermal fracture of ceramic materials under quasi-static thermal stresses (Ring Test)" by W. R. Buessem and E. A. Bush; "Effect of porosity on thermal stress fracture" by R. L. Colbe and W. D. Kingery; "Effect of shape on thermal fracture" by E. M. Baroody, E. M. Simons, and W. H. Duckworth; "Thermal shock analysis of spherical shapes" by W. B. Crandall and J. Ging.

Extensive references, experimental data, and mathematical derivations, all are included. Attention is paid to the problems of heat transfer and temperature distribution, of elastic stress distribution, and their significance in terms of the probability of fracture. There is a consistent effort to get down to fundamentals rather than to depend upon purely empirical tests.

D. C. Drucker, USA

78. Zoller, K., Thermal stress during heating of a drum (in German), *Ing.-Arch.* **23,** 51–60, 1955.

In a rather long-winded paper, author considers an infinite cylindrical shell with outer wall insulated, inner wall subject to a temperature distribution $\theta(t)$. The heat-transfer coefficient is finite. Graphs are given for inner and outer face temperatures when $\theta(t)$ is a step function. Temperatures are found throughout the wall by interpolation, and Duhamel's theorem is used to determine the temperature distribution when θ is of form $a + bt$ for $0 < t < t_n$, and $a + bt_n$ for $t > t_n$. Formulas for the consequent stresses are given, and a numerical example, with superimposed pressure stresses, is worked out. G. Horvay, USA

79. Melan, E., Stresses due to nonsteady temperature fields (in German), *Öst. Ing.-Arch.* **9,** 2/3, 171–175, 1955.

A general expression for subject two-dimensional stresses is given in terms of the thermoelastic displacement potential. As illustration, thermal stresses due to sudden application of heat at a point in a large thin disk are found. Results are of interest in connection with spot welding. L. E. Goodman, USA

Experimental Stress Analysis

(See also Revs. 59, 60, 64, 121)

80. Durelli, A. J., Lake, R., and Ōkubo, S., A grid method to determine strains in rubber-like material, *Proc. second U.S. nat. Congr. appl. Mech.,* June 1954; Amer. Soc. mech. Engrs., 1955, 291–295.

Paper describes the use of rubber latex threads as gage lines for determining strains in elastomer specimens under tensile loading. The threads are cemented to the specimen and photographs taken at intervals during the test. Measurements are considered accurate to ±0.0002 in. Method provides both longitudinal and transverse strains, true stress, and "natural" strain.

W. Shelson, Canada

81. Palermo, P. M., Performance of waterproofing compounds applied to electrical resistance strain gages subjected to hydrostatic pressure, *David W. Taylor Mod. Basin Rep.* no. 760, 19 pp., Dec. 1954.

Experiments have been performed to find a method of waterproofing strain gages subjected to hydrostatic pressure which is

quick, economical, and reliable and which requires a minimum amount of special skill on the part of the workman. Three of the more promising methods are described in detail.

From author's summary

82. Kuipers, M., Calculation and design of the measuring elements (in Dutch), *Ingenieur* **67,** 26, 89–100, July 1955.

After a short survey of the properties of strain-gage instruments and the related conditions which the measuring elements must comply with, the current types of the latter ones—such as cylinders, bars, membranes, cantilever springs, and rings—and their fields of application are discussed. Finally, more specific numerical details are given about the end effect of cylinders, strains and stresses of rings and membranes.

From author's summary

83. Itō, K., On new materials for three-dimensional freezing photoelasticity, and their application (in Japanese), *Rep. sci. Res. Inst.* **30,** 4, 233–248, July 1954.

As new materials for three-dimensional photoelastic measurement by freezing method, some network polymers which cure by polymerization without volatile by-products are investigated. Epoxy resin, diallyl phthalate homopolymer, unsaturated polyester resin which is co-polymerized with styrol, divinyl benzol, allyl ester (especially diallyl phthalate), triallyl cyanulate monomer, etc., are closely re-examined, mainly from the standpoint of Foster's figure of merit. Examples are given showing how certain polymers, whose photoelastic sensitivity becomes reversed in sign in transition from a room temperature to a freezing temperature, can be used with great advantage.

Courtesy of Kagaku-Kenkyu-Jo Hōkoku Abstracts Summary

84. Jessop, H. T., Snell, C., and Holister, G. S., Photoelastic investigation in connection with the fatigue strength of bolted joints, *Aero. Quart.* **6,** part 3, 230–239, Aug. 1955.

The elastic stress distribution around a circular hole in a flat bar under simple tension when the hole is filled by a push-fit pin, was investigated photoelastically. Over a range of values of the ratio of hole diameter to width of bar, and for pins of differing Young's moduli, the effect of the pin was sensibly the same, namely, to reduce the maximum tension on the hole boundary by about 15%, as compared with that in the unfilled hole.

The maximum shear stress on the boundary was unaltered.

From authors' summary

Rods, Beams, Cables, Machine Elements

(See also Revs. 42, 43, 58, 61, 62, 104, 138, 151)

85. Koloušek, V. Z., Dynamics of continuous beams and frame structures [Baudynamik der durchlaufträger und rahmen], translated from Czech into German by Mühl, W. (technical edition by the author and Bebr, A.), Leipzig, Fachbuchverlag GMBH, 1953, 217 pp.

Author considers the essential part of his book, completed after 10 years' study and research, as an original contribution to dynamics of continuous beams and frames, which has been considerably neglected in the past although movable loads seriously affect the safety of many structures. Vibration effects on frame structures have been previously studied by the energy method; other methods were used by Reissner, Hohenemser, and others. However, some problems could not be solved by these methods. Author uses the method of deformations which, to a certain extent and only for simpler cases, was previously used by E. Fliegel, N. I. Besuchow, and A. A. Belous. This method is applied for the first time by the author for analyzing vibrating systems subjected to statical direct forces, for determining the effect of shear, energy of rotation, and damping vibration of two- and three-dimensional frames. Furthermore, some simplifications are introduced in the analysis by the energy method.

Chap. I reviews other typical methods and should be completed in the next edition by methods recently developed, especially in the U. S. (Saibel, D'Appolonia, Hoppmann, Looney, Gaskell, Conwell). In other chapters the following subjects are thoroughly discussed: II: Principles of author's deformation method; free and forced vibrations, axial and transverse vibrations of structural types with straight and curved members and with constant and variable moment of inertia. III: Simplifications of the energy method. IV: Analysis of damped vibration by energy method and by operational calculus and comparison of the results. V: Influence of shear, rotational inertia, and axial forces of structural members, demonstrated on framed foundations of machines. VI: Comparison of vibration effects with buckling. VII: Application of virtual work and its reciprocity, the latter being used only for structural types with equal frequency of oscillation; formulas are derived expressing the reciprocity under statical axial forces and damped vibration. VIII: Effect of moving loads, especially acting on continuous railroad bridges. IX: Oscillation of three-dimensional frameworks, especially of those with cyclic symmetry. Chap. X contains tables of functions for determination of resulting forces and moments of various types of oscillating structural members which considerably simplify the calculations (53 pages).

Impact effects are not discussed in this book which, as the author states, will be followed by another volume which will present more complicated cases of structural dynamics as, e.g., suspension bridges, high chimneys, enclosed elastic spaces, etc. Some of the problems were presented by the author at the Third Convention of the International Association for Bridge and Structural Engineering, Liège, 1948. J. J. Polivka, USA

86. Moody, K. G., and Viest, I. M., Shear strength of reinforced concrete beams, Part IV—Analytical studies, *J. Amer. Concr. Inst.* **26,** 7, 697–730, Mar. 1955.

Results of tests on 136 simple and restrained rectangular beams, with and without web reinforcement, failing in shear, were reported earlier and are analyzed in this paper. From the reported tests, it was found that to predict the shear strength of a reinforced-concrete beam, two analytical expressions are required: (1) for the load at which diagonal tension cracks form, and (2) for the load at which the compression zone of concrete is destroyed. The solution of the first problem, the cracking load equation, was obtained from test data as an empirical expression for the nominal shearing stress corresponding to the maximum shear; the second problem, the ultimate strength equation, was solved by a semirational expression in terms of the ultimate moment at the failure section. From authors' summary

87. Horvay, G., and Born, J. S., The use of self-equilibrating functions in solution of beam problems, *Proc. second. U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 267–276.

In a previous paper [AMR **6,** Rev. 3018], Horvay studied stresses in a semi-infinite rectangular strip by making use of the

Ritz method. Now the authors present analysis for obtaining approximate solutions in a beam of finite length. Forces acting only on one edge are specially considered.

To understand this paper it is necessary to be familiar with Horvay's previous paper, which is often referred to.

G. Supino, Italy

88. Moenart, P., Experimental study of failure of long reinforced concrete beams loaded with longitudinal eccentric load acting on a symmetry axis of the cross section (in French with Dutch summary), *Ann. Trav. publics Belç.* **106,** 4, 5, 6; 509–566, 701–754, 840–896, Aug., Oct., Dec. 1953.

The comprehensive introduction contains a detailed report on the experimental work done so far concerning eccentrically loaded reinforced-concrete cross sections, as well as a review of different suggested methods for calculating such beams (the classical method, those of Prof. Saliger, Gebauer, Brandtzaeg, Steuerman, Mörsch). Making use of the results of earlier investigations by the authors mentioned and those conducted at Brussels University, author puts forward a new method for calculating such eccentrically loaded beams, a method based on the hypothesis that, in a cross section, the tensions change as a function of deformations in the same way as they do on the edge of section girder.

After an analysis of earlier methods suggested and the one of his own, author comes to the conclusion that: (1) Using the earlier methods, the problem has been satisfactorily solved for practical purposes in cases where, at failure, the elastic limit of steel had already been exceeded (the methods of Prof. Saliger, Brandtzaeg, and Gebauer); (2) in cases where the elastic limit of steel had not been reached, all the methods failed to prove exact enough; (3) the method suggested by author answers the purpose in both cases (1) and (2), giving, with reference to results obtained by tests, a total dispersion up to 7%.

D. Krsmanović, Yugoslavia

89. Barta, J., On the estimation of torsional rigidity, *Proc. k. Ned. Akad. Wet.* **(*B*) 58,** 1, 80–89, 1955.

A new approximate method is established, applicable for elastic prismatic rods with simply and multiply connected cross sections. The method, compared with others, is advantageous, as it gives the lower and upper limits for the numerical value of torsional rigidity. The range between these limits depends on proper selection of a certain arbitrarily chosen single-valued starting function $U(x,y)$ approximating Prandtl's torsional stress function. The complete derivation of final formulas is described. A few numerical examples are included. Economically reachable accuracy: The mean value differs from the exact value by a few per cent.

K. Julis, Czechoslovakia

90. Sukharevskiĭ, I. V., On the problem of torsion of a composite, multiply connected bar (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **19,** 107–124, 1954.

The problem discussed is that of torsion of a composite bar, the components of which have different elastic properties. In the author's words: "The basic result of this paper consists in the construction and investigation of a single-valued, solvable integral equation, the solution of which immediately gives the distribution of tangential stress on the contour."

Author proceeds to derive an integral equation which is in a different form than that given by N. I. Muskhelishvili. The existence of nontrivial solutions is discussed and it is shown that the displacement vector can be taken in the same form as torsion of a homogeneous bar. Author points out that the investigation of the integral equation would have been conducted using the general results obtained by N. I. Muskhelishvili.

Sufficient conditions for solving the integral equation by successive approximations are given in the form of a theorem. It appears that the author's results are applicable to regions of a less restricted character than those previously given. Two illustrative examples are worked out.

B. S. Wilson, USA

91. Black, P. H., Machine design, 2nd ed., New York, McGraw-Hill Book Co., Inc., 1955, viii + 471 pp. $7.50.

Prof. Black's book is written predominantly from the design point of view rather than the analysis approach. The topics covered are for the most part those which are traditional in test books on this subject. The book is shorter than most, but is well written. The appendix contains various useful tables and considerable information on stress concentration effects in shafts and bars. The short chapter on vibration is a beginning mathematical treatment—simple spring-mass systems.

The chapters on loading, induced stresses, stress concentration, and failure are more complete than most other machine-design texts and are well illustrated. The problems at the back of the book have evidently been selected with care to illustrate some of the practical considerations of design.

This book has much to recommend it as a text for a short course in machine design.

W. J. Carter, USA

92. Zwahlen, R., Calculation of curved plate springs for elastic clutches (in German), *Schweiz. Bauztg.* **72,** 47, 48, 681–684, 695–699, Nov. 1954.

Main feature of paper is development of curved beam relations in a form to take account of effects of curvature change caused by loading. The final third of the paper, contributed by G. Elger, applies the theory to design of springs for a flexible coupling. Results of theory are compared with tests of the springs.

A. S. Hall, USA

93. Armagnat, M. P., Computation concerning lifting hooks (in French), *Mem. Soc. Ing. civ. Fr.* **108,** 2, 121–134, Mar./Apr. 1955.

Author is concerned with developing simple analytical methods for determining safety factors and comparing qualities of lifting hooks of different shapes under static conditions. The importance of taking into account the mode of attachment of the load to the hook is strongly emphasized. Simple methods for calculating stresses and safety factors in hooks are given and examples are worked out. Author attempts to assess significance of errors resulting from approximations.

J. L. Ericksen, USA

94. Erismann, T., Theory and application of friction sphere gears (in German), *ZAMP* **5,** 5, 355–388, 1954.

Author's aim is to clarify relations and principles in friction sphere gears in order to make possible the study of problems connected with their design and development.

The sphere is supposed to be freely movable about its (fixed) center and in contact with a certain number of rollers, whose axes are fixed (Festrolle), or can rotate about a radial axis containing (Schwenkrolle), or not containing (Schlepprolle), the point of contact.

Possible combinations and dispositions of the several rollers defining the motion of the sphere are first examined and some fundamental kinematical connected relations are given.

Taking into account, in a simplified way, the local flattening (Hertz), the percentage of variation between theoretical and effective sphere-roller speed ratio is calculated.

Some possible uses of sphere friction gears are briefly pointed out (integration of a function, of its reciprocal, of its integer

powers, of the product of several functions; harmonic analysis; vibration filter; 1st and 2nd derivatives; continuous speed ratio, etc.).

Finally, referring in particular to the several stages of development of a sphere integrator, it is shown how useful the aforesaid principles are in critical selection and rational improvement of the various practical possible solutions.

Reviewer believes this paper constitutes a clear outline of the principles and possibilities of friction sphere gears.

R. Giovannozzi, Italy

95. **Rothman, M., Note on the problem of an infinite wedge under a general polynomial law of boundary loading,** *J. roy. aero. Soc.* **59,** 529, 61–63, Jan. 1955.

This note gives the stress distribution in an infinite wedge subject to a general polynomial law of loading along either edge. The method used is that of complex potentials.

From author's summary

Plates, Disks, Shells, Membranes

(See also Revs. 8, 9, 63, 64, 65, 78, 106, 107, 116, 323)

96. **Tiffen, R., Some problems of thin clamped elastic plates,** *Quart. J. Mech. appl. Math.* **8,** part 2, 237–250, June 1955.

Paper deals with problems of transverse displacements of thin elastic plates occupying the following regions: (a) half planes; (b) those which can be mapped conformally on to a half plane; (c) infinite strips, the boundaries being clamped. Investigation aims at general methods rather than particular solutions. Proofs of uniqueness are given, with emphasis on the difficulties in the case of materials extending to infinity in some, but not all, directions. Problems of isolated interior loading are considered for all the above types of region.

From author's summary by A. D. Topping, USA

97. **Fung, Y. C., and Wittrick, W. H., A boundary layer phenomenon in the large deflexion of thin plates,** *Quart. J. Mech. appl. Math.* **8,** part 2, 191–210, June 1955.

In the bending of a flat thin plate with large deflections, there is an anticlastic curvature which, however, has been shown by Ashwell [AMR **4,** Rev. 1069] to be more and more confined to a narrow region, or boundary layer, near each free edge as the paremeter b^2/Rt increases ($2b$ width of plate, t thickness, R longitudinal radius of curvature). Present paper attempts to generalize this concept to other problems less amenable to rigorous analysis, such as bending of cantilever plates and torsion of a rhombic plate. The applicability of the results to thin swept wings is discussed.

A. D. Topping, USA

98. **Lekhnitskiĭ, S. G., Stress distribution in an anisotropic plate with an elliptical plugged hole (plane stress)** (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* 19, 83–106, 1954.

Author gives a general solution of plane stresses in an anisotropic infinite plate with an elliptical hole plugged with another elastic anisotropic material. The plug is either welded around its contour or simply cemented in. The plate is subjected to deformation due to forces applied to the edges and acting in its middle plane. The solution is of an approximate nature. The plate and plug are assumed to be of the same thickness, but of different anisotropic materials. The dimensions of the plug are small in comparison with those of the plate. The distribution of the forces along the edges of the plate may follow any desired law, but there are no forces acting along the contour of the plug. The material follows Hooke's law. It is first assumed that the stresses and displacements are known for a plate without discontinuities and without a plug, and the additional stresses are established due to the presence of the plug.

The following special cases are also considered: (1) An orthotropic plate with a circular plug, the plate being in tension in one direction and in all directions; (2) simple shear; and (3) pure bending. All cases are analyzed for plates with a hole, hole filled with a rigid plug, and hole filled with an elastic plug. Tables and graphic presentation of stress distribution around the plug are given for each case showing the comparative values of the stresses. The distribution of stresses and displacements are chosen in such a way as to satisfy the conditions of the contours and, away from the plug, should reduce to the stresses of a homogeneous plate without a plugged hole. Numerical examples illustrate the proposed approximate method.

M. Maletz, USA

99. **Crawford, R. F., and Libove, C., Shearing effectiveness of integral stiffening,** *NACA TN* 3443, 37 pp., June 1955.

An integrally stiffened plate under twisting, shearing, and a combination of both is studied. The coefficients q and c, expressing, respectively, the effectiveness of the stiffeners in resistance to shear and to combined twisting and shear, are determined with the aid of an electric analog computer. Results of the numerical computations covering a range of combinations of rectangular stiffeners with circular fillets are presented in tables and curves. From these coefficients, the elastic constants associated with the twisting and shearing of the integrally stiffened plate may be calculated. Two examples are included, indicating that the fillet radius contributes appreciably to the degree of penetration of the stresses from the skin into the stiffeners.

T.-T. Loo, USA

100. **Malkina, R. L., Calculation of pipes with arbitrary cross section** (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **19,** 141–148, 1954.

A variation of Novoshilov's method [cf. "Theory of thin shells," Sudpromgiz, 1951] for the calculation of cylindrical shells of noncircular cross section is developed. It is assumed that the tube is loaded by a constant internal pressure and that arbitrary boundary conditions are given at the ends. Stresses and deformations are derived from a complex function, which is developed in a Fourier series, as are the deviations from a circular cross section. In the case of jointed ends, a system of algebraic equations is derived, whereas in the case of arbitrary boundary conditions a system of ordinary differential equations of fourth order with constant coefficients results.

W. Wuest, Germany

101. **Rosenblueth, E., Shell reinforcement not parallel to principal stresses,** *J. Amer. Concr. Inst.* **27,** 1, 61–71, Sept. 1955.

Current methods of shell design implicitly assume that concrete can take tension. In intermediate steps those methods strive to satisfy strain relationships. The procedure developed herein consistently assigns no tension to the concrete and only takes into account considerations of equilibrium, not strain relationships. The procedure requires the addition and subtraction of stress tensors, which is greatly simplified through the use of Mohr's diagram. It is applicable only to states of pure axial or "membrane" stresses.

From author's summary

102. **Karas, K., Calculation of rotating disks of prescribed profiles** (in German), *Öst. Ing.-Arch.* **9,** 2/3, 157–171, 1955.

In continuation of the Donath procedure, a method is developed which allows graphical and analytical determination of

the state of tension in disks of an alleged profile. Thereby the disk is replaced by a graded stair profile. By a suitable transformation, one obtains, instead of the Donath diagram, with curves of the second and fourth order, just two ordinary hyperbolas. The state of stresses at rest is caught hold of by simple elementary straight lines.

From author's summary by A. M. Guzmán, Argentina

103. Shiratori, E., and Sasaki, S., Strength of high-speed rotating disks (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 103, 181–186, 1955.

Buckling Problems

(See also Rev. 63)

104. Meissner, F., Some computational results of the theory of lateral buckling of simple symmetrical beams (in German), *Stahlbau* **24,** 5, 110–113, May 1955.

Title problem is treated with a Fourier series for the lateral angular deflection, the two first coefficients of which are determined by means of the Ritz method as applied to a variational problem due to E. Chwalla [*S. B. Akad. Wiss. Wien,* 1944]. All beams considered are simply supported at the ends and prevented from lateral deflection at the ends only. All loads are applied in the plane of symmetry. Four loading cases are considered: uniformly distributed, concentrated at the middle, one-sided, and double-sided end moments. Sectional constants are given for channel beams and simple symmetrical I-beams.

F. K. G. Odqvist, Sweden

105. Link, H., On the straight, buckling beam with limited bending (in German), *Ing.-Arch.* **22,** 4, 237–250, 1954.

Paper gives an interesting analysis of the buckling process of an initially straight beam, loaded in compression, placed between two parallel rigid plane walls, at the same small distance from each wall. Simple beam theory, neglecting shear deformation, is used. Frictional forces, wherever present, are not taken into account. Beams with simply supported and clamped ends have been investigated.

If, after exceeding the Euler buckling load, the deflected beam reaches a wall, the curvature of the beam decreases there until a straight portion appears, supported by the wall. The length of this straight portion increases until a limit of stability is reached. Then the beam buckles again, but now it is a snap-through process. The buckling process can proceed with decreasing compression load, due to increasing buckling length. At constant compression load the deflections grow until the beam reaches the opposite wall. J. F. Besseling, USA

106. Rao, C. L. A., The influence of body forces on the stability of a reinforced rectangular plate, *J. roy. aero. Soc.* **59,** 534, 437–441, June 1955.

Buckling of reinforced rectangular plates in the presence of body forces is investigated by use of strain energy method. The small deflection theory is assumed and the results are presented in the form of three graphs. H. H. Hilton, USA

107. Seth, B. R., Stability of rectilinear plates, *ZAMM* **35,** 3, 96–99, Mar. 1955.

Author shows that the critical thrust for the stability of a simply supported rectilinear plate, under the combined action of transverse load and edge thrust, corresponds to the least eigenvalue of transverse vibrations of a clamped membrane having the same boundary as the plate. G. Herrmann, USA

Joints and Joining Methods

(See also Rev. 285)

108. Radcliffe, B. M., and Suddarth, S. K., The Purdue-Illinois nail-glued roof truss with a pitch of 2:12 for spans of 24′8″ and 28′8″, *Purdue Univ. Agric. Exp. Sta. Bull.* no. 621, 18 pp., Mar. 1955.

The glued gusset plates used for this roof truss greatly increase the stiffness of the truss. Deflections under load are considerably smaller than those for a nailed or bolted structure. There are practically no residual deflections for the glue-nailed trusses for loading and unloading tests with $2^1/_2$ times a design load of 40 lb per sq ft. From authors' summary

109. Marian, J. E., and Suchsland, K., Experimental investigation of gluing and finishing problems through application of fluorescence microscopy in incident light, *Sven. TräforskInst. Medd.* **69** B, 5 pp., 1955.

Existing methods of preparation of samples of glued wood and surface films for microscopic observation in translucent light on slides are unsatisfactory. A procedure is described for preparing samples for visual observation or photography by incident light fluorescence microscopy, adequate for the application to gluing and finishing problems. From authors' summary

110. Ferreira, H. N., Strength of joints between new and old concrete (in Portuguese), *Bol. ord. Engenheiros* **4,** 3, mem. no. 74, 13 pp., 1955.

This report presents the results obtained from a series of tests made to ascertain the strength of joints between new and old concrete.

Various methods of preparing the surface of the old concrete were studied, as were the interposition of mortar, the humidity of the old concrete, its age, and the horizontal or vertical position of the surface or its inclination in relation to the axis of the test specimen.

The work is based on an analysis of the values of the stresses—and their dispersion—obtained from bending tests on small beams.

Finally, types of joints for new or reconstruction works are suggested. From author's summary

111. Eickner, H. W., Weathering of adhesive-bonded lap joints of clad aluminum alloy, *WADC AF TR* 54-447, Pt. 1, 14 pp., Feb. 1955.

112. Hartman, A., The influence of low temperature on the strength of redux bonded single lap joints of 24 and 75S-T clad (in Dutch), *Nat. LuchtLab. Amsterdam Rep.* M 1973, 16 pp. + xiv, Dec. 1954.

The principal tests carried out to determine the influence of low temperature on the shear strength of redux-bonded simple lapjoints of 75S-T or 24S-T alclad sheet were short-time tensile tests at room temperature, −20 C and −55 C, and long-time tensile tests at room temperature and at −55 C. For both alloys at −55 C the short-time strength had diminished to about 65% of the strength at room temperature. The short-time strength at room temperature was not significantly affected by prior long-time loading below the long-time strength either at room temperature or at −55 C. The long-time strength at −55 C was at least as good as the long-time strength at room temperature. The long-time strengths at room temperature appeared to be very sensitive to the curing cycle of the adhesive. A slight undercuring of the adhesive could easily be detected. Rapid fluctua-

tions in temperature between +50 and −55 C did not have any influence on the shear strength of the joints at room temperature.
From author's summary

113. **Kontkiewicz, R., The first Polish spot-welding machine for reinforcements—work of a rationalization team** (in Polish), *Przegl. tech.* **75,** 4, 125–128, Apr. 1954.

Structures

(See also Revs. 44, 86, 88, 99, 108, 110, 143, 144, 146, 150, 163, 181 213, 266, 289, 309, 336, 339, 340)

114. **Das Baul, R., Exact solution of statically indeterminate frame structures containing members with absolutely variable moments of inertia by the fixed point method,** *J. Instn. Engrs., India* (1) **35,** 4, 415–462, May 1955.

An analytical method of solution is presented for frames with members whose moment of inertia is expressible as a function of distance from one end of the member in the form $J^x = f(x)^{-1}$. Using notations given in Ernst Suter's "Methode der Festpunkte," equations are derived for the moments in statically indeterminate frames. Extension of the method to irregular loads and cross sections is illustrated by using a strip approximation and summation technique. Reviewer believes that value and philosophy of paper is best described in author's words: ". . . . this method, as all other 'exact' methods, is a lengthy one, and for practical designs too laborious to adopt, particularly, because this method involves determination of complicated integrals. But, the author feels from his practical experience that a designer should work out his first problem in indeterminate frame structure by the exact method so that, as he applies any of the 'approximate' methods in his subsequent designs, he may be conscious of his limits."
R. M. Spath, USA

115. **Ohno, I., Stress distribution at the corner of a stiff frame,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 101–104.

Brahtz's method [*Trans. Amer. Soc. civ. Engrs.* **101,** p. 1240] is used to obtain an approximate solution for the stress distribution at the inner boundary of the corner of a rigid frame. Only pure bending is considered in this paper. The effects of shearing and normal forces are explained in a later paper.
J. Michalos, USA

116. **Terrington, J. S., The torsion centre of girders: Application of shell analysis to structural sections,** *Engineering* **178,** 4635, 688–691, Nov. 1954.

Paper discusses briefly the written theory relating to beams which are subjected to bending and torsion, discusses the center of rotation of asymmetrical open-sided structural sections, and re-examines an example based on the author's original paper, "The determination of the shear centre in asymmetrical girders," B.I.S.R.A. paper PE/E/34/54.
C. O. Dohrenwend, USA

117. **Morgan, V. A., Analysis of single-bay gable frames,** *Concr. constr. Engng.* no. 7, 249–259, July 1955.

118. **Whitney, C. S., Anderson, B. G., and Cohen, E., Design of blast construction for atomic explosions,** *J. Amer. Concr. Inst.* **26,** 7, 589–695, Mar. 1955.

Methods and principles used in designing the first full-scale blast resistant structures tested at Eniwetok are presented and the test results are cited in support of the procedures outlined. Economic and other practical considerations are discussed. Radiation hazards and methods of dealing with them are described.

Appendixes are included which give detailed procedures for computing the blast loading, for designing individual structural elements and single and multistory buildings in both the elastic and plastic range for this loading, for computing ultimate strength of structural elements and frames under rapid loading, and for dealing with some special problems.
From authors' summary

119. **Ziegler, H., The problem of long spans (concrete and steel bridges)** (in German), *Öst. Ing.-Arch.* **9,** 2/3, 250–262, 1955.

Limitations of bridge spans are presented in theoretical way and paper is a valuable contribution to the important problem which has been previously discussed from practical point of view by F. Stüssi. Since for long spans the effect of typical live load is negligible compared with dead load, author's mathematical investigations are limited to the latter. Basic equations of arches with constant compressive stress—Coriolis arches—for variable rise-span ratios are developed, their coefficients expressed by series, and the results presented graphically and tabulated. So, e.g., for the lowest rise-span ratio, $HL = 0.05$, the maximum and most economical spans would be 820 ft in concrete and 2500 ft in steel. For the ratio $HL = 0.5$ these arch spans increase to 5300 and 16,000 ft, respectively, assuming permissible stresses 2000 and 20,000 psi, respectively. All investigations are made for bridges composed of slender elements. Reference is made to publications by K. Federhofer, B. L. Bierberbach, and S. M. Feinberg.

Reviewer believes that the study of this problem should be extended to other important factors than the permissible compressive stress of the material used, such as lateral forces, buckling, dynamic effects, etc.
J. J. Polivka, USA

120. **Massonnet, Ch., Completion of the calculation of multibeam bridges** (in French), *Ann. Trav. publics Belg.* **107,** 5, 679–748, Oct. 1954.

Author completes method of Guyon for calculating multibeam bridges with transverse girders in two important ways: First, by considering torsional rigidity of beams and taking into account different bending rigidity of border beams. Paper gives an introduction to the method, which is based on substituting the grid with a continuous system. Applying theory of anisotropic plates we obtain—with a sinusoidal distribution of load—a closed solution for deformations and moments.

Author presents a large number of tables for calculating transverse distribution of lineal load by means of two parameters: Θ (factor of grid rigidity) and α (factor of torsional rigidity). Method is also applicable for nonsinusoidal load and even for concentrated load, except of very large bridges which require application of series.

Reviewer points out that use of the presented tables permits rapid calculation of stresses in multibeam bridges, which is of great practical importance. A recent work of K. Sattler [*Bauingenieur*, 1955, p. 77) extends application of tables also to external statically indeterminate structures.
H. Beer, Austria

121. **Serafim, J. L., Uplift in dams [A subpressão nas barragens],** *Minist. Obras Públ., Lab. Engen. civ. Lisboc Pub.* **55,** xx + 243 pp., 1954.

Book studies forces resulting from entrance of water under pressure into the body of concrete dams and their foundations.

Chap. I is a general survey of the problem and of subjects dealt with in the book. Chap. II studies nature of uplift with reference to some conceptions: Maurice Levy's criterion based on presence

of cracks, Fillunger's principle of uplift forces resulting from variation of pore pressure, Terzaghi's theory of "boundary porosity" as a characteristic of concrete irrespective of volumetric porosity. Tests made by McHenry, Leviasvky Bey, and R. Davis are described, and references are made to regulations and codes for calculation of uplift forces.

Chap. III studies true significance of boundary porosity and establishes differential equations of elasticity between pore pressure and stresses among particles. A remarkable and useful analogy with stresses produced by temperature variations is found. Assuming validity of D'Arcy's law, the unsteady flow of water is studied in chap. IV. Equations show that existence of air in concrete is more important than compressibility of water or deformability of concrete. Reference is made to Laplace equations of steady flow of water in porous media, and methods of solution (in particular, iteration methods) are studied and used in practical applications.

In chap. V, tests concerning flow of fluid through porous media, and physical properties of Portland cement, are concerned. In chap. VI, references are made to measurement of pore pressure in dams. Tests carried out for determination of boundary porosity of mortar and Portland cement paste are described in chap. VII.

Reviewer believes that this is a clear and up-to-date work about the subject. Thorough description of methods and plenty of numerical data give special interest to the book.

H. F. Long, Argentina

122. Rocha, M., Serafim, J. L., da Silveira, A. F., and Neto, J. M. R., Model tests, analytical computation and observation of arch dam, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. 696, 38 pp., May 1955.

123. Anonymous, Slide gate tests, Norfork Dam, North Fork River, Arkansas, *Wwys. Exp. Sta. tech. Memo.* 2–389, 25 pp. + xix tables, + xxxxviii plates, 1 appendix, July 1954.

Results of full-scale tests at Norfork Dam of the two types of slide gates, selected on the basis of model tests, indicated that the performance of a gate with a 45° upstream bevel at the lower edge (type B) was superior to that of the Norfork-type gate (type A) which had a flat bottom with a slight slope to fit the sealing surface. High negative pressures on the gate bottom, considerable gate vibration, and crackling sounds characteristic of cavitation were noted for most gate openings of the Norfork gate. By contrast, high positive pressures occurred over the sloping bottom of the 45° gate, resulting in elimination of cavitation sounds and in a marked reduction in gate vibration. The high positive pressures also resulted in less air demand at partial gate openings.

Tests of long duration at partial gate openings with both test gates revealed some cavitation damages to the outer edge of the bronze seals on both sides of the gate frame and to the cast steel immediately downstream and just under the gate.

From summary

124. Anonymous, Tainter gate tests, Norfork Dam, North Fork River, Arkansas, *Wwys. Exp. Sta. tech. Memo.* 2–387, 27 pp. + xxviii tables + xxxiv plates, June 1954.

Results of full-scale tests of a tainter-type control gate under high-head conditions conducted at Norfork Dam, Ark., indicated that the hydraulic performance of either the fixed trunnion- or eccentric trunnion-type gate was satisfactory. Pressures on the gate and in the immediate vicinity thereof were positive. Fluctuations of pressure were small and were maximum at full gate opening. Vibration and downpull measurements were difficult to obtain, as seal friction appeared sufficient to influence both to a considerable degree. Visual observation of both type gates revealed no objectionable vibration characteristics. Analysis of data, model and prototype, also indicated that hydraulic downpull forces were small.

Difficulty was experienced with the initial type of seals investigated with the fixed trunnion-type gate; these seals were actuated by water pressure from the reservoir. This difficulty was alleviated by use of a pneumatically operated gate seal. The use of the eccentric trunnion-type gate provided postive sealing action, and no trouble was encountered.

From summary

125. Rużycki, S., How can we achieve economy of construction (in Polish), *Przegl. tech.* **75,** 9, 327–328, Sept. 1954.

126. Walls, J. H., An experimental study of orifice coefficients, internal strut pressures, and loads on a small oleo-pneumatic shock strut, *NACA TN* 3426, 23 pp., Apr. 1955.

Measurements of shock-strut internal pressures, telescoping velocity, and strut stroke were made during drop tests of a small oleo-pneumatic landing gear to determine the characteristics of the orifice and to show the relationships between internal strut pressures and the over-all loads developed by the strut. The variation of the orifice coefficient with telescoping velocity and strut stroke is presented. Strut forces determined from internal-pressure measurements are compared with forces measured by an external dynamometer. Strut forces calculated from measured telescoping velocity and stroke time histories are evaluated, a constant orifice coefficient and isothermal air compression being assumed.

From author's summary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 39, 166)

127. Predvoditelev, A. A., and Smirnov, B. A., Theory of dynamic creep, *NACA TM* 1330, 12 pp., Sept. 1955.

A theory of one-dimensional creep at time-variable stress is proposed, starting point being a theory by R. Becker [*Z. techn. Phys.* **7,** p. 547, 1926]. As a result of plastic deformation in one grain and its weakening, the rest of the body receives an additional load and corresponding deformation, which Becker assumes to follow Hooke's law but here is given a more general form. From their calculations, which in their highly compressed form are extremely difficult to follow, authors find an increase in creep of materials under cyclic creep loads, said to be confirmed by experience. No reference is given. It should be mentioned that Becker's theory in its original form has been recently refuted by O. D. Sherby and J. E. Dorn [AMR **8,** Rev. 3060].

F. K. G. Odqvist, Sweden

128. Neville, A. M., Theories of creep in concrete, *J. Amer. Concr. Inst.* **27,** 1, 47–60, Sept. 1955.

Various theories of creep in concrete are critically reviewed. It is suggested that creep is due to more than one cause, notably to viscous flow with a gradual transfer of load to the aggregate, and to moisture movement due to evaporation and external force, this movement being of the nature of increased shrinkage as compared with a similar unloaded specimen.

From author's summary

129. McMickle, R. H., and Kubu, E. T., Diffusion controlled stress relaxation, *J. appl. Phys.* **26,** 7, 832–838, July 1955.

The action of water solutions of dimethyl formamide on Dinitrile A fibers was studied using the stress-relaxation technique. After prior conditioning and stress relaxation in water, the addi-

tion of dimethyl formamide-water solutions produced an exponential stress relaxation. It was found that the rate and extent of stress relaxation in dimethyl formamide-water solutions are dependent on the dimethyl formamide concentration. The rate of stress relaxation in dimethyl formamide-water solutions is also dependent on the cross-sectional area and the state of orientation of the fiber. These data can best be explained by postulating that the rate of diffusion of the dimethyl formamide-water solution into the fiber controls the rate of stress relaxation. The diffusion coefficient is found to be concentration dependent, and the diffusion process has an activation energy of 14 kcal.

From authors' summary

130. **Wang, A. J., and Prager, W., Plastic twisting of a circular ring sector,** *J. Mech. Phys. Solids* **3,** 3, 169–175, Apr. 1955.

Fully plastic twisting of a circular ring sector of an arbitrary solid cross section is discussed. Graphical methods for the determination of the shear lines and the rate of warping are developed. Square and rectangular cross sections are treated as examples.

From authors' summary by G. W. Housner, USA

131. **Oding, I. A., and Ivanova, V. S., Characteristics of diffusion plasticity in stress relaxation of metals** (in Russian), *Izv. Akad. Nauk Otd. Tekh. Nauk* no. 5, 81–90, May 1954.

Authors attribute relaxation to processes of two types: (1) diffusion processes, by which initial stress σ_0 drops (in 10^1 to 10^3 hr) to $S_0\sigma_0$, $S_0 < 1$; (2) mechanical processes (e.g., slip, rotation of mosaic blocks), by which stress slowly decreases further according to law $\sigma = S_0\sigma_0 \exp(-t/t_0)$. Authors regard (1) as intergranular and (2) as intragranular. They cite examples of practical utility of this separation into two parts, but now seek more information about nature of (1).

They first study the temperature dependence of S_0. By simplified theory they deduce that, for a diffusion process, $1 - S_0 = BT^{-1} \exp(-Q/RT)$ (B and Q constants, R gas constant, T absolute temperature). Data on several steels at four temperatures are consistent with this relation; deviations for one steel are attributed to aging. Authors next consider two classes of diffusion process: (a) self-diffusion of atoms into vacancies, along direction of maximum shear stress; (b) diffusion of interstitial atoms into locations for which the stress creates a preference. Unloading causes reverse diffusion in (b) but not, authors state, in (a). Tests on several steels at 630 C show an aftereffect explicable by such reverse diffusion. Authors conclude that experiments support interpretation of early part of relaxation curve as diffusion process, partly or wholly of class (b).

William Fuller Brown, Jr., USA

132. **Mentel, T. J., Plastic deformations due to dynamic loading of a beam with an attached mass,** *Canad. J. Technol.* **33,** 4, 237–255, July 1955.

The large plastic deformations of a homogeneous beam subjected to static or dynamic pressure loading have been investigated by Lee, Symonds, and others [AMR **6,** Rev. 1531; **7,** Rev. 1789] by means of the "plastic-rigid type analysis." This analysis makes the assumptions of negligible elastic strain and of rigid body motion of segments of the beam, joined at plastic hinges, where the entire body motion takes place.

In the present paper, author uses the same analysis to study the effect of a mass attached to the beam. The particular cases worked out are those of a simply supported and a built-in beam, subjected to a uniform pressure pulse of a rectangular shape. The motion which is more complex than for the uniform beam is analyzed in detail and it is shown, for example, that near the attached mass a reversal of sign of the plastic flow may take place if the load is large enough. This behavior is considered of possible significance for the tendency of the beam to fracture.

In a final section, author discusses the accuracy and limitations of simple one-dimensional models for the title problem.

H. L. Oestreicher, USA

133. **Dugdale, D. S., Experiments with pyramidal indenters, I, II,** *J. Mech. Phys. Solids* **3,** 3; 197–205, 206–211, Apr. 1955.

Some of the factors involved in relating indentation hardness to the shear yield stress of the material are investigated. Author suggests that, for a frictionless pyramidal indenter with a given vertex angle, the ratio of indentation pressure to shear yield stress will be the same for all rigid-plastic materials. There should be another ratio for "rough indenters." Experiments were carried out on manganese steel, cold-rolled copper, and silicon-aluminum, using square pyramidal indenters. Tests on copper with triangular pyramids are also quoted.

Shear-stress shear-strain curves were obtained by torsion and compression tests.

Indentation pressures were corrected for the effects of friction by using experimentally determined values of the coefficient.

Experimental results for the three materials tested lend support to author's hypothesis. F. Ellis, England

134. **Shield, R. T., Plastic flow in a converging conical channel,** *J. Mech. Phys. Solids* **3,** 4, 246–258, July 1955.

The flow through a conical channel is analyzed for a rigid-plastic material obeying a general yield condition of the form $f(J_2, J_3)$. The solution is then specialized for a material which obeys either the von Mises or Tresca yield condition, and the corresponding results are studied in some detail.

The author also presents an approximate solution to the problem of wire drawing based on the afore-mentioned solution.

B. W. Shaffer, USA

135. **Alexander, J. M., The effect of Coulomb in the plane-strain compression of a plastic-rigid material,** *J. Mech. Phys. Solids* **3,** 4, 233–245, July 1955.

The plane strain solution to the compression of a slab of material between two rigid plates was studied for the two plate-width to material-thickness ratios, b/t, of 7 and 3, respectively, by making use of the geometric construction previously proposed by Prager in AMR **6,** Rev. 3731. In each case, the author investigated a number of solutions corresponding to either a constant coefficient of friction at the material-plate interface or a constant shear stress equal to k, the maximum shear stress of the material. The latter condition, of course, applied to that portion of the material-plate interface for which the coefficient of friction times the normal stress was calculated to be greater than the numerical value of k.

It was shown that the ratio of average plate pressure for b/t equal to 7 and 3 is a single-valued function of the coefficient of friction within the range studied. The author suggests that this fact may provide an experimental means of estimating the coefficient of friction at the material-plate interface.

An approximate analysis to the problem was also presented which appears to give equivalent results for $\mu < 0.15$.

B. W. Shaffer, USA

136. **Hershey, A. V., The plasticity of an isotropic aggregate of anisotropic body-centered cubic crystals,** *NPG Rep.* 1384; *NAVORD Rep.* 1342, 1–90, June 1955.

Paper extends author's previous work on polycrystalline aggregates. It is assumed that the slip plane is the plane of maximum

shear stress, that an average of three slip systems operate, and that local deviations of stress and strain from the average are proportional to each other. Calculations show that the plastic potential is of the von Mises type. The model does not give good results for deformation textures.

J. F. W. Bishop, Scotland

137. Kayan, I., Plastic torsion problem and residual stresses for the regular hexagonal cross-sectioned prismatical bars by relaxation methods, *Bull. tech. Univ. Istanbul* **6,** 6, 45–61, 1953.

Elastic, elastoplastic, and plastic torsion of a bar of hexagonal cross section are discussed. Southwell's relaxation process is used for all three studies, with an equilateral triangular net being employed. The mesh used is relatively fine, consisting of sixteen points along each side of the hexagon. The elastic case is considered first and the problem is formulated in terms of the usual Saint Venant theory. Using relaxation methods, the torque angle of twist and also the torque-maximum shear stress relations are obtained. Using the concept of Prandtl's proof the elastoplastic problem is next investigated, again by numerical methods, and the boundaries of the elastic-plastic interface are established for various torques. The case of purely plastic action is investigated and the ultimate load-carrying capacity of the bar is formulated in terms of the yield point of the material. Finally, residual stresses corresponding to the unloading of various torques causing elastoplastic action are calculated. Unfortunately, warping of the cross section is not discussed for any of these cases.

W. A. Nash, USA

138. Green, A. P., A theory of the plastic yielding due to bending of cantilevers and beams, Part II, *J. Mech. Phys. Solids,* **3,** 2, 143–155, Jan. 1955.

The group of solutions for the plastic yielding of cantilevers of rectangular cross section described in part I of this paper [AMR **8,** Rev. 3392] is completed here by consideration of the effect of weak end support under conditions of plane stress. These solutions are applied to the problems of yielding of centrally or uniformly loaded beams, either fixed at both ends or simply supported. The plane stress solutions are applied to corresponding problems for beams of I-section, bent about an axis perpendicular to the web. The theoretical deformation modes for cantilevers are shown to agree well with experiments by Hundy and Frankl. Empirical equations obtained for the shear loads under I-beams are roughly confirmed by some experiments of Hendry.

From author's summary by P. G. Hodge, Jr., USA

139. Filonenko-Borodich, M. M., On the conditions of the strength of materials possessing different tensile and compressive strengths (in Russian), *Inzhener. Sbornik, Akad. Nauk SSSR* **19,** 13–36, 1954.

In introduction, author gives some critical comments on Mohr's theory of strength. A lack in this theory is the disregarding of influence of the principal stress σ_2. Author starts with assumption that strength at a given point depends on each of principal stresses σ_1, σ_2, σ_3, and supposes therefore that boundary of the "strength range" is formed (in space σ_1, σ_2, σ_3) by a surface

$$\phi(\sigma_1, \sigma_2, \sigma_3) = 0 \qquad [1]$$

Author leaves the form of the function [1] not fixed, with the assumption only that surface [1] cuts equal abscissas—corresponding to (simple) tensile strength—on positive axes σ_1, σ_2, σ_3, and equal abscissas—corresponding to compressive strength—on the negative ones. This is surely fufilled if equation [1] is of the form

$$F(\vartheta_1, \vartheta_2, \vartheta_3) = 0, \qquad [2]$$

where ϑ_1, ϑ_2, ϑ_3 are elementary symmetrical functions of σ_1, σ_2, σ_3. Special forms of functions [2] give a set of surfaces. Author takes some (simple) of them under investigation, determining free constants in such a manner that certain points of these surfaces would correspond to experimental results. He shows that some of the surfaces correspond to known results given by other theories (Mohr's theory, Mises-Hencky's theory, etc.). In this sense, it can be said that the theory presented by the author is a generalization of these theories.

K. Rektorys, Czechoslovakia

140. Novozhilov, V. V., Class of strain paths characterized by the invariability of principal directions (in Russian), *Prikl. Mat. Mekh.* **18,** 4, 415–424, July/Aug. 1954.

Article deals with strain paths producing an elastic-plastic deformation, characterized by the invariability of principal directions during the whole process of deformation. The investigation of such strain paths is of interest in so far as they permit a relatively simple experimental checking. It is also shown that in this case a fairly simple theory of integration of Reuss equations can be given. Author quotes an article by L. Guy and J. Merin dealing with the same problem from another point of view.

From author's summary by D. Radenković, Yugoslavia

141. Ree, T., and Eyring, H., Theory of non-Newtonian flow. I, Solid plastic system, *J. appl. Phys.* **26,** 7, 793–800, July 1955.

The relaxation process of viscous flow may be visualized as the sudden shifting of some small patch on one side of a shear surface with respect to the neighboring material on the other side of the shear surface. Any shear surface will divide a mosaic of such patches lying on the two sides of the surface. Except for the simplest systems, this mosaic of patches will be heterogeneous and can be described by groups each characterized by its mean relaxation time β_n, by x_n, the fractional area of the shear surface which the group occupies, and by α_n, a characteristic shear volume divided by kT. The resulting generalized expression for viscosity is

$$\eta = \sum_{n=1}^{n} \frac{x_n \beta_n}{\alpha_n} \frac{\sinh^{-1} \beta_n \dot{s}}{\beta_n \dot{s}}$$

where $\dot{s}$ is the rate of shear. This equation is applied to masticated natural rubber, polystyrene, X-672 GR-S, X-518 GR-S rubber, and Vistanex LM-S polyisobutylene. All applications give good agreement with experiment. The known criticisms of Eyring's simple relaxation theory for viscous flow are reviewed and are apparently taken care of in this general treatment.

From authors' summary

142. Ree, T., and Eyring, H., Theory of non-Newtonian flow. II, Solution system of high polymers, *J. appl. Phys.* 26, 7, 800–809, July 1955.

Authors' theory developed in part I (see preceding review) is applied to solutions of polystyrene, polyisobutylene, X-518 GR-S rubber, and lime base grease with good agreement with experiment. The parameters x_n/α_n and β_n (see preceding review), were calculated and are tabulated; these parameters are proportional to the surface concentration and the relaxation time of the nth group of flow units, respectively. The effects of the molecular weights of polymers, concentration, solvent, and temperature on these parameters were studied. Results establish the following facts:

(1) The heterogeneity of flow units increases with increasing molecular weight.

(2) In the range of low concentration, β_n (relaxation time) is independent of concentration, while the areal concentration of non-Newtonian units increases more rapidly than proportional to the bulk concentration of a polymer.

(3) A "good" solvent increases the concentration of non-Newtonian units, while the contrary is true for a "poor" solvent.

(4) In poor solvent solutions, the concentration of non-Newtonian units increases with increasing temperature, while the concentration is independent of temperature in good solvents.

From authors' summary

Failure, Mechanics of Solid State

(See also Revs. 69, 77, 84, 85, 88, 127, 131, 136, 162)

143. Tye, W., The outlook on airframe fatigue, *J. roy. aero. Soc.* **59,** 533, 339–348, May 1955.

Author gives general review of airframe fatigue problem, in particular of fixing a safe value of fatigue life. He points out various gaps in knowledge on this subject; e.g., on gust frequencies at low altitudes, operational characteristics of airplane, validity of cumulative damage hypothesis and variation of life of nominally identical structures. He finally discusses means to improve the situation, mentioning improvement of materials in respect to fatigue strength and scatter, detail design methods, and structural arrangements and stress levels which avoid fatigue failure being catastrophic. F. J. Plantema, Holland

144. Smith, I., Howard, D. M., and Smith, F. C., Cumulative fatigue damage of axially loaded alclad 75S-T6 and alclad 24S-T3 aluminum-alloy sheet, *NACA TN* 3293, 49 pp., Sept. 1955.

Report presents the results of cumulative-fatigue-damage tests made on 607 specimens machined from alclad 75S-T6 aluminum-alloy sheet 0.064 in. thick and 198 specimens of alclad 24S-T3 and alclad 75S-T6 aluminum-alloy sheet 0.032 in. thick. The tests of the 0.064-in.-thick specimens consisted of 35 different loading conditions and the tests of the 0.032-in. material consisted of 13 different loading conditions. The stress amplitudes used were nominally ±16,000 and ±17,000 psi, ±16,000 and ±30,000 psi, ±16,000 and ±60,000 psi, ±30,000 and ±40,000 psi, and ±30,000 and ±60,000 psi.

The cumulative-damage ratio was calculated as the sum of the ratios of the numbers of cycles applied at the different stress levels to the number of cycles at the same stress level that would cause failure. Seventy-two per cent of the average cumulative-damage ratios were within 20% of unity, and 40% were within 10% of unity. The smallest average cumulative-damage ratio of a group of four similar specimens was 0.568 and the largest, 1.440. The cumulative-damage ratios for the 0.032-in.-thick material showed no systematic variation from those for the 0.064-in. material. From authors' summary

145. Klaasen, W., and Hartman, A., The fatigue diagram for fluctuating tension of single lap joints of clad 24S-T and 75S-T aluminum alloy with 2 rows of 17S rivets, *Nat. LuchtLab. Amsterdam Rap.* M 1980, 4 pp. + xix, April 1955.

On two-row snap-riveted single lap joints of clad 24S-T and 75-S-T aluminum alloy with 0.8-mm sheet thickness, 3-mm rivet diam, and 20-mm rivet spacing, the fatigue diagram for fluctuating tension has been determined for endurances ranging from 10^4 to 50.10^6 load cycles. At all stress levels the riveted 24S-T alclad specimens had better endurances than the riveted 75S-T clad specimens. The fatigue diagram was compared with results given in the literature. From authors' summary

146. DeSousa, Coutinho A., Cracking of cements, mortars, and concretes, produced by shrinkage (in Portuguese), *Minist. Obras Publ., Lab. Engen. civ. Lisboa Pub.* no. 57, 137 pp., 1954.

This paper deals with the study of cracking in cements, mortars, and concretes under restrained shrinkage. In the method used, both free and restrained shrinkage (that is, the stress produced by it) are measured. For this purpose, two rings are cast: one is free and the other is cast around a metallic ring which constitutes the means to maintain the constant strain of the concrete specimen. The metallic ring is provided with vibrating wires in order to be able to measure the stress in it and consequently the stresses in the mortar or concrete.

Author gave particular consideration to creep and found that, in order to have high cracking strength, it is fundamental to have high strength concretes; such concretes have lower creep, but the influence of strength σ_r is more important than the developed stress in the restrained-shrinkage specimen.

Book presents a large amount of data resulting from long series of tests, in which the influence of many variables are systematically studied. It will prove to be very useful to research people dealing with concrete properties.

From author's summary by A. J. Durelli, USA

147. Miller, W. R., and Jackson, H. R., Atoms trace the wear, *Lubrication Engng.* **11,** 4, 238–241, July/Aug. 1955.

148. Hundere, A., Lawrason, G. C., and O'Meara, J. P., Neutrons, gamma rays, and wear, *Lubrication Engng.* **11,** 4, 230–236, July-Aug. 1955.

149. Kerridge, M., Metal transfer and the wear process, *Proc. phys. Soc. Lond.* (B) **68,** part 7, 427B, 400–407, July 1955.

Experiments have been made with a radioactive annealed steel pin rubbing against a hardened steel ring to compare the amount of wear with the amount of metal transferred from one surface to the other by welding. It was found that a layer of transferred matter from the pin was formed on the surface of the ring and that an equilibrium condition was reached in which the loss of wear debris from this layer was balanced by further transfer. By using a combination of radioactive and inactive test pieces, the rate of transfer to the ring in the equilibrium condition could be estimated and was found to be the same as the wear rate of the pin. There was no evidence that any loose wear particles were formed by direct removal of material from the pin. The transferred layer became oxidized due to frictional heating and it is concluded that the wear process consisted of three stages: transfer of metal, oxidation of the transferred layer, and the subsequent removal of the oxide to form a loose wear product.

From author's summary

Material Test Techniques

(See also Revs. 80, 88, 121, 160)

150. Kotanchik, J. N., Johnson, A. E., Jr., and Doss, R. D., Rapid radiant-heating tests of multiweb beams, *NACA TN* 3474, 30 pp., Sept. 1955.

Four multiweb box beams were subjected to radiant heating at rates up to 90 Btu/ft² sec. The heating was unsymmetrical (only one cover of each beam was heated) and no external loading was applied during heating. Measured temperatures in the covers and webs are given. Thermal stresses buckled the covers while the beams were being heated, and the webs as the beams were cooling. The temperatures at which buckling of the covers occurred were approximately the same for beams with ribs as for

beams without ribs. Measured strains in the webs were used to determine bending distortions and stresses. Stresses at buckling were found to agree with those predicted by an elementary thermal-stress analysis. A description of the rapid-heating apparatus is presented.

From authors' summary by R. Mela, USA

151. **Mavis, F. T., and Richards, F. A., Impulse testing of concrete beams,** *J. Amer. Concr. Inst.* **27,** 1, 93–102, Sept. 1955.

The purpose of this study was to find out whether reinforced-concrete beams that are identical except for grade of reinforcement behave alike or differently under identical impulses; and if they behave differently, how much—and why?

Structural-grade bars, and hard-grade bars that had been rolled with identical deformations from a billet of rail steel, were obtained from the same manufacturer. Beams were cast in gang molds with structural-grade and hard-grade bars alternating in adjacent beams. After the preliminary tests, concrete was supplied by truck mixer in large enough quantities so there should be no question about uniformity of concrete in any one batch.

A new testing machine was designed and built to apply identical impulses to two beams in any given test, and instruments and methods were devised to record what happened at any instant during a test. Things that occurred simultaneously were recorded photographically at a rate of 64 exposures per sec; and charts were synchronized to show load-deflection-time data with comparable precision. From authors' summary

152. **Philippoff, W., and Brodnyan, J., Preliminary results in measuring dynamic compressibilities,** *J. appl. Phys.* **26,** 7, 846–849, July 1955.

In order to supplement dynamic measurements in shear and bending, the vibration tester of the Franklin Institute Laboratories was used to measure the bulk compressibility of plastics using harmonic vibrations. Polyethylene and plasticized polyvinyl chloride were investigated. The values of the compressibility were comparable to the static values as far as they are known. A noticeable phase shift between pressure changes and volume changes could not be detected with certainty so that the bulk modulus B in dynes/cm^2 is not a complex quantity. Especially for the polyethylene, a temperature range from -25 to $+95$ C and a frequency range from 0.0003 to 5 cps were used. The isothermals obtained could be shifted together using the method of reduced variables of Ferry. From the frequency shifts a_T, an activation energy of 60 kcal/mole was obtained.

From authors' summary

153. **Phillips, C. W., and Sinnott, M. J., A statistical study of the stress-rupture test,** *Trans. Amer. Soc. Metals* **46,** 63–86, 1954.

A large number of replicate stress-rupture tests have been made on 2S aluminum at 900 F. The variation in fracture time and reduction in area at a given stress may be represented by a logarithmic-normal distribution, while the elongation distribution is normal. The standard deviations in log fracture time, log reduction of area, and elongation have been determined and found to be considerably larger than is generally recognized. The linearity of the log-stress log-time plot in the vicinity of the break in the rupture curve is uncertain. The break in the rupture curve cannot be explained by the simple hypothesis of recrystallization. Aluminum during testing deforms and recovers by a process of subgrain formation. From authors' summary

154. **Dawance, G., and Chefdeville, J., Acoustic measurements on concrete; new methods for determination of the quality of concrete by measuring sound velocity** (in German), *Schweiz. Arch.* **21,** 7, 223–234, July 1955.

155. **Rohde, F. W., Development of the new post-emulsion fluorescent penetrant inspection,** *J. Soc. nondestructive Testing* **13,** 4, 27–34, May/June 1955.

156. **Tolmon, F. R., and Hall, J. F., Diamond indentors for Rockwell-hardness testing. Further developments in their precision measurement,** *Engineering* **178,** 4637, 760–762, Dec. 1954.

In a previous paper, an account was given of methods developed at the National Physical Laboratory for the measurement of the angle of the cone and the radius of the tip of diamond indenters used in Rockwell-hardness tests. Some further developments have since been made at the Laboratory and these are described in the present paper, which includes also a brief statement of the experience gained in the inspection of indenters during the past few years. From authors' summary

Mechanical Properties of Specific Materials

(See also Revs. 30, 68, 69, 77, 108, 110, 111, 112, 128, 129, 131, 141, 142, 144, 145, 151, 152, 153, 154, 156, 172, 331)

157. **Hirschfeld, E., Cemented carbides,** Zurich, Schwizer Druckund Verlagshaus A. G., 1949, 264 pp., 90 fig., 36 tables.

The reviewed textbook, written by the chief machining engineer in Czechoslovakian SKODA Works and professor at Bratislava University, is a complete course in cemented carbides. After a short introduction, author explains in part I the "Principles of machining" (definitions, chip pressure, cutting temperature, tool life, limits of rentability). Part II, "Cemented carbides," deals with the development of tool materials, the principles of powder metallurgy, and the nomenclature and properties of cemented carbides. Part III discusses "Carbide application" (with stress on good organization and suppression of possible blunders), while part IV deals with "Various problems created by carbide introduction," and concerns the machine tools, tool housekeeping, investment policy, etc. The final part V discusses the "Bases for an economical carbide application."

As a whole, the reviewed textbook is based chiefly on German and Czech development (especially the semiofficial recommendations of the German Board for Productivity, AWF), but it includes also much information from American and Russian sources. The book is, most probably, unique in its kind and approach. It is a very complete carbide course and a well-done bridge between machining research and production shop. The personal opinion of its writer, stressing the importance of proper organization, tool housekeeping, and investment policy, is of greatest merit. The book includes a large and well-done index of bibliographical references in various languages. The present German edition follows two previous Czech editions. A. Niedzwiedzki, USA

158. **Hausner, H. H., and Kells, M. C., Powder metallurgy—its role in the design of nuclear-power reactors,** *Mech. Engng., N. Y.* **77,** 8, 665–669, Aug. 1955.

159. **Sato, M., An experimental study on the change in Young's modulus of quenched carbon steel due to wetting by liquids,** *J. sci. Res. Inst. Tokyo* **49,** 1376/1390, 1–3, Mar. 1955.

The change in Young's modulus of a quenched carbon steel due

to wetting by several liquids is studied experimentally, showing that the modulus is lowered by a group of liquids, while the reverse is the case with another group.

From author's summary

160. Dove, R., and Murphy, G., Experimental technique for predicting the dynamic behavior of rubber, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-41, 9 pp.

161. Sutter, Lillian, and Straka, Leora E., Engineering developments of rubber, July, 1953—August 1954, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-256, 15 pp.

162. Zak, A. F., and Manko, Iu. P., Effect of temperature on the deformation and strength of glass fibers (in Russian), *Zh. tekh. Fiz.* **24,** 11, 1983–1990, Nov. 1954.

163. McLaud, E., and Gustafson, F., Design limits for polyester-glass laminates, *Prod. Engng.* **25,** 8, 161–168, Aug. 1954.

Mechanics of Forming and Cutting

(See also Revs. 49, 133, 134, 135, 159)

164. Garofalo, F., and Low, J. R., Jr., The effect of prestraining in simple tension and biaxial tension on flow and fracture behaviour of a low carbon deep-drawing steel sheet, *J. Mech. Phys. Solids* **3,** 4, 275–294, July 1955.

The effect on plastic flow and fracture of prestraining a fully killed deep drawing steel sheet was investigated by first applying a tensile force to the sheet and then pulling a series of specimens taken at five different positions with respect to the direction of the original prestrain. The effect of biaxial prestrain was also considered by taking a series of specimens from sheet steel which had been previously used either in circular or elliptical hydraulic bulge testers.

On the basis of these tests, author makes the following conclusions: The initial anisotropy of the material which satisfied orthotropic symmetry, was not affected by prestrain. After prestraining under biaxial tension, or upon changing the direction of straining after some prestraining, the initial flow stress was found to be greater than that predicted by the effective stress-strain concept, and the rate of strain hardening was found to decrease. Furthermore, the fracturing characteristics of the material seemed to be unaffected by the prestraining process.

B. W. Shaffer, USA

165. Thomsen, E. G., A new approach to metal-forming problems, *Trans. ASME* **77,** 4, 515–522, May 1955.

Lead was extruded in a split die at room temperature into a tube by the incremental inverted process in order to follow the distortion of intersecting grid lines along a meridian plane of a sectioned billet. Direction and magnitude velocity were determined at various grid intersections, intermittently, by photography and enlargement ten times billet size, which permitted evaluation of strain rates in cylindrical coordinates and principal strain directions. Usual assumptions were made, such as sum of plastic normal strains are equal to zero; Mohr's stress circles are proportional to strain circles; only first terms of relation between displacement and strain are necessary; equilibrium equations are valid; Lévy-Mises plasticity equations are valid for lead, using effective stresses and strains; and effective stress is a constant.

Compression tests showed that the change of effective stress versus strain rate increased approximately linearly with strain rate. Equilibrium equations were rewritten in terms of strain rates to solve for the axial stress gradient.

No detailed description is given of pressure-measuring device and its usefulness.

This method requires several hundred hours of computation in addition to experimental work, but it is a fine contribution to experimental plasticity, especially metal forming problems.

H. Majors, Jr., India

166. Hundy, B. B., and Singer, A. R. E., Inhomogeneous deformation in rolling and wire-drawing, *J. Inst. Metals* **83,** 7 pp., 1954–1955.

Microhardness measurements made on copper, 70:30 brass, aluminum, and mild steel indicate that there is an analogy between the inhomogeneity of deformation rolled strip and that in drawn wire. Copper, brass, and aluminum all show surface-hardening when lightly rolled or drawn. The inhomogeneity is dependent on the working conditions, and disappears after moderate reductions by rolling or drawing. The surface-hardening is caused by frictional forces acting between the rolls or die and the metal, and increases as the coefficient of friction increases. In general, a specific surface hardness can be associated with definite frictional conditions.

Rolling and drawing also give rise to a secondary zone of hardening situated between the core and the surface of the metal. This can be observed in both copper and steel, and it does not decrease in magnitude as the reduction is increased. It is believed that secondary hardening is associated with the manner of deformation during rolling and drawing, and is largely independent of friction.

From authors' summary

167. Shaffer, B. W., The mechanics of the simple shearing process during orthogonal machining, *Trans. ASME* **77,** 3, 331–336, Apr. 1955.

Author presents a continuation of earlier work on finding the force system acting on the tool, chip, and workpiece during orthogonal cutting of a continuous chip by the theory of plasticity. The maximum shear stress acting along the shear plane is used to determine shear stresses in the chip and especially at the tool face. However, the experimental verification of author's theoretical discussion is difficult because (a), as the author himself points out, the value of a maximum shear stress is too sensitive to variations in strain rate, size effect, and temperature, and (b) it has since been shown experimentally by Thomsen that shearing also takes place along the tool-chip interface and therefore the question arises whether another shear plane of yield conditions exists along that surface. If that is so, then Mohr's circle cannot be used for determining the shear force on the tool face. J. Frisch, USA

168. Stabler, G. V., Some aspects of the metal cutting process (Symposium on metal-working oils. Part I, Metal cutting), *J. Inst. Petrol.* **40,** 369, 256–260, Sept. 1954.

The action at the point of a tool is reviewed and the importance of the shear and friction phases of the cutting process stressed. Topics briefly reviewed include the built-up edge, discontinuous and partially discontinuous chip formation, chip curvature, power consumption, and intermittent cutting.

M. C. Shaw, USA

169. Kaczmarek, J., Quick cutting and paring with Kolesov type tools (in Polish), *Przegl. tech.* **75,** 3, 94–98, Mar. 1954.

170. Luboński, J., and Szczepiński, W., Methods of blanking sheet metal parts used in aircraft industry (in Polish), *Techn. Lotn.* **9,** 1, 12–16, Jan./Feb. 1954.

171. Fersing, L., and Smith, D. N., Machinability research with J&L tool dynamometer on titanium 150A, *Trans. ASME* **77,** 1, 65–77, Jan. 1955.

172. Yang, C. T., and Shaw, M. C., The grinding of titanium alloys, *Trans. ASME* **77,** 5, 645–660, July 1955.
See AMR **8,** Rev. 687.

173. Andreasen, A. H. M., and Jensen, I. H., Crushing mills with regard to the theory of similitude (in German), *ZVDI* **96,** 33, 1117–1120, Nov. 1954.

Comparison of large and small crushing machines can be carried out relatively simply with the help of the similarity principle and model experiments. Crushing machines working on different principles function adequately provided that the rpm changes inversely with the size. In the case of Koller mills and sphere mills (Kugelmuhle), the weight of the milling body must be inversely proportional to the size of the mill if the efficiency of the crushing procedure is to be the same. Experiments have been carried out to clarify the similarity relations between the obtained fineness and between the required power and energy.

From authors' summary by F. Hinsenkamp, Hungary

Hydraulics; Cavitation; Transport

(See also Revs. 121, 123, 124, 187, 190, 191, 209, 211, 212, 214, 253, 259, 348, 349, 350)

174. Hoyt, W. G., and Langbein, W. B., Floods, Princeton University Press, 1955, ix + 469 pp. $7.50.

This fascinating book, written by two outstanding authorities in hydrology of the U.S., outlines one of most destructive phenomena of our life, a menace to national welfare. Book is of particular importance to hydraulic and municipal engineers, as flood protection presents a very difficult problem. Authors sketch development of the flood and discuss how population can adapt to the nature of the flood, prevent disaster, and protect against destruction. Book not only emphasizes technical aspects, but presents extensive historical information on floods since 1543. Specific problems, projects, and plans in every basin of the U.S. are explained by facts from the past. One of controversial questions is whether there may exist a certain maximal probable flood at a given point, or whether any flood is possible there with a definite probability of its occurrence. An illustrative example (fig. 19) shows the effect of two aspects and explains a casual misjudgment. Text is highly readable and accompanied by flood pictures. Reviewer regrets that content is limited to the U.S.; study of kindred events around the world would contribute to harnessing wild nature. S. Kolupaila, USA

175. Hayashi, T., Experiment of flood waves, *Proc. 2nd Japan nat. Congr. appl. Mech., 1952;* Nat. Committee for Theor. appl. Mech., May 1953, 277–281.

The investigation deals with the experimental evidence of a theory which appears worthy of interest, although the theory itself has been summarized too briefly.

The theoretical analysis refers to the propagation of flood waves in a uniform channel. In order to generalize the solution, author gives the equation of the law of the phenomenon with dimensionless parameters. He introduces the parameter $\sigma = \sqrt{(\partial^2 H/\partial t^2)_0}/\sqrt{gI}$ in which $(\partial^2 H/\partial t^2)_0$ is the vertical acceleration of the water level of the crest of a flood wave at a cross section at $t = 0$, g the acceleration due to gravity and I the slope of the channel. The parameter σ takes into account the curvature of the flood wave in the vicinity of the crest.

Author gives the solution of these equations by a method of successive approximations in terms of σ and of a particular value of the Froude number F. He arrives at the evaluation of the factor of the attenuation λ of the flood wave and of the speed w of propagation of the wave in terms of σ and F. In the second part of the paper, author reports the experimental results of tests carried out in a channel approximately 33 m in length with cross-sectional dimensions of 30 × 40 cm and different longitudinal slopes. With the aid of a properly designed valve at the bottom of the constant level tank, a flood wave of any shape could be generated.

The too-concise description of the experimental setup leaves some uncertainties about the manner in which the measurements have been carried out, chiefly as far as the readings of the instantaneous value of the water depths are concerned. The results are to be considered in agreement with the theoretical analysis within the limit of accuracy of the experimental apparatus.

A. Russo-Spena, Italy

176. Uchida, S., On the analysis of flood wave in a reservoir by the method of characteristics, *Proc. 2nd Japan nat. Congr. appl. Mech.,* 1952; Nat. Committee for Theor. appl. Mech., May 1953, 271–276.

Equations of characteristics of the differential system of motion in a channel are generalized for every shape of cross section; in particular, the case of a monomial relation between depth and area is examined. Graphical solution is outlined; initial and boundary conditions are indicated for the flood passage through a reservoir. An example is given, controlled by experience, showing the effect of out-flow conditions on the deformation of flood waves.

D. Citrini, Italy

177. Minnesota International Hydraulics Convention, Proceedings, Part III. Density currents, Inter. Assn. Hydr. Res., Hydraulics Div. Amer. Soc. civ. Engrs.; Univ. Minn., Minneapolis, Minn., 305–400, Sept. 1953.

In this collection of seven instructive articles by various authors, the subjects treated are, in brief, stability of interfaces, mixing mechanism, classification of mixing, estuarial and tidal currents, observations in Port Niigata, Japan, and interpretations, internal waves and internal hydraulic jumps, control action of the mouth of estuary, intrusion of salt into estuary, TVA experiences, density currents in Lake Mead, observations in Lake Sautet, France, and interpretations, and laboratory investigation of interfacial stresses of the laminar origin. G. H. Keulegan, USA

178. Wickert, G., Problems of tidal power utilization (in German), *VDI-Forschungsheft* **446,** 40 pp., 1954.

179. Escande, L., Superimposed oscillations in a surge tank, friction losses being neglected (in French), *C. R. Acad. Sci. Paris* **239,** 1, 5–8, July 1954.

An instantaneous opening of the turbines causes surges in the surge tank. If t is the time, $T = 2\pi/\omega$ the period, the oscillations are $Z = -Z_0 \sin \omega t$. When a rapid reclosing occurs at time t_0, the surges in the tank are a new series of sine oscillations. For $t_0 = T/2$, dangerous interference may occur, which the author analyzes.

C. Jaeger, England

180. Mikhailov, G. K., Simplification of the method of calculating seepage in uniform anisotropic soil (in Russian), *Inzhener. Sbornik. Akad. Nauk SSSR* **19,** 159–160, 1954.

Uniformly anisotropic soil is defined as "anisotropic soil, the

coefficient of seepage of which, along each direction, remains constant." Elliptical equation for seepage pressure head is solved by a transformation of coordinates and introduction of a fictitious field of isotropic seepage flow. Example illustrates method.
V. L. Dutton, Canada

181. **Kuntzmann, J., and Bouvard, M., Theoretical study of bottom-type water-intake grids** (in French), *Houille blanche* **9**, 5, 569–574, Sept./Oct. 1954.

Paper discusses discharge received and discharge discarded by the grid of a water intake at the bottom of a torrent. Differential equation is obtained by making simplified hypotheses, and integration of this equation is outlined. Curves for the calculation of a screen are presented. Comparisons with experimental results (Orth, Meynardi, Chardonnet, title source, **8**, 3, p. 343, 1954) and with results from the method of successive approximations (Bouvard, op. cit., **8**, 2, p, 290, 1954) are given.
From authors' summary

182. **Kermeen, R. W., McGraw, J. T., and Parkin, B. R., Mechanism of cavitation inception and the related scale-effects problem,** *Trans. ASME* **77**, 4, 533–541, May 1955.

Although essentially a progress report on studies of cavitation inception scaling, paper presents valuable information on effect of velocity, size, and some fluid properties on inception. Theoretical analysis indicates cavitation number K is not the only significant parameter for defining inception. Initial water tunnel tests on airfoils of 2-, 4-, and 8-in. chord indicated that inception number K_i varied with size and test velocity and that Reynolds number did not correlate the variation.

The rest of the studies reported were of similar families of axisymmetric bodies. Tests in the CalTech water tunnel and the large one at Penn State of bodies $^1/_2$ to 8 in. in diam indicate that K_i increases with model size and velocity. For "streamlined" noses it approaches the minimum pressure coefficient on the body. Tests of bluff bodies (disks) show that Reynolds number is the significant scaling parameter. In this case the inception cavitation number is greater than the minimum pressure coefficient. Thus use of pressure coefficient to predict K_i is conservative for streamlined shapes but not for blunt.

Detailed studies of cavitation inception on streamlined bodies indicate that bubbles originate on the surface within boundary layer. They grow to a size about equal to the displacement thickness and then are transported to point where inception is usually noted macroscopically. Utilizing special techniques to avoid cavitation in piezometers, pressure measurements indicated existence of tensions in the water.

In the discussions it is noted that these studies show that cavitation bubbles which have been reported as rebounding [cf. Knapp and Hollander, AMR **1**, Rev. 1285] were, in reality, pulsating air bubbles. Reynolds number dependency for a model at different temperatures is shown, but authors note there is no clear one for different sizes. Conflicting reports on the effect of air content on cavitation are noted.

Reviewer concurs with authors that these studies have given significant new information concerning mechanics of cavitation inception. Paper is a must for anyone interpreting cavitation tests on models.
J. M. Robertson, USA

183. **Winter, H., Contribution to the hydraulic branching problem** (in German), *Öst. Ing.-Arch.* **9**, 2/3, 239–249, 1955.

As is well known, the hydraulic branching problem deals with the splitting of a liquid or gas stream into partial streams, or the fusion and discharge of partial streams into a reservoir, as well as with the combination of these two problems. Since it is the distribution problem in particular that has not found a satisfying solution until now, a way is shown in this first partial report of solving this problem for a particular form of the distributor for which it has given satisfying results. Being applicable in principle to other cases also, this method will allow an extension to the complete branching problem, which will be given in the second partial report.
From author's summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 180, 182, 183, 215, 218, 219, 220, 221, 226, 232, 234 237, 239, 241, 251, 255, 263, 265, 299, 326, 342, 343, 347)

184. **Miesse, C. C., Correlation of experimental data on the disintegration of liquid jets,** *Indust. Engng. Chem.* **47**, 9 (part II), 1690–1701, Sept. 1955.

For the combustion of fuel sprays, as it occurs in internal combustion engines, in gas turbines, and in liquid-propellant rockets, the disintegration of the liquid jets is of fundamental importance. During the past hundred years a large number of experimental researches have been made on sprays, and numerous attempts were made to correlate the experimental results by means of theoretical analyses, based on fundamental properties of the liquids and the surrounding medium. Author analyzes a number of these existing theories, namely those of Rayleigh, Weber, and Tomotika, which are based on the small disturbance of a liquid jet surface, influenced by the surface tension of the liquid, its viscosity, its kinetic energy, and hydrodynamic velocity potential. Tomotika considered the viscosity ratio to be of prime importance, and produced useful correlations for low-velocity jets. Author then analyzes the work of Tyler, Holroyd, Littaye, and others whose endeavor was to correlate the secondary atomization of liquid drops by means of reasoned conjectures, such as the assumption that the breakup of the drops occurs when the drag forces exceed the inertia forces. Finally, the author analyzes the investigations based on dimensional analysis of Ohnesorge, Baron, Haenlein, Borodin and Dityakin, Probert, and others.

After all this searching study, possibly one of the most penetrating in recent years, author comes to the conclusion "that the total problem of jet integration, which results in a measurable distribution of droplet sizes, is by no means solved, nor are the related problems of droplet ballistics and evaporation, or combustion. Outstanding among the missing links are the effects caused by the properties of the ambient atmosphere: density, relative velocity, viscosity, pressure, and temperature. . . Nor have the problems of secondary atomization, droplet-size distribution, combustion effects, and properties of jet bundles been solved satisfactorily. A wide-open field has been left for future theoretical research."
K. J. De Juhasz, Germany

185. **Girardin, P., Secondary effect of a jet on a self-propelled engine** (in French), *C. R. Acad. Sci. Paris* **240**, 8, 843–845, Feb. 1955.

Analysis is made of the forces of the jet acting on a self-propelled engine which is experiencing a rotation about an axis orthogonal to the longitudinal axis of the engine. In this case a force results which is orthogonal to the previously mentioned axes and which has an effective point of application midway between the center of gravity and the plane of ejection. According to the author, this point of application is worthy of special notice. The analysis is approximate because of the simplifying assumptions, but the result obtained furnishes an upper limit for the effect considered.
W. C. Johnson, Jr., USA

186. Tesson, F., Kinematics of systems with variable number of particles (in French), *C.R. Acad. Sci. Paris* **240,** 8, 845–850, Feb. 1955.

The ordinary laws of mechanics and thermodynamics apply to systems comprising the same set of particles in different states of motion, and, in the case of continuous media, they are limited by a closed surface which may change with time. In this article author analyzes systems with a variable number of particles defined by a particular surface of which the position is known at each instant with respect to a reference point R. The case in which a surface of the latter type is fixed with respect to R is of interest in self-propulsion. One of the equations developed is shown to check that in the article by Girardin which precedes this one in the *Comptes Rendus* (see preceding review).

W. C. Johnson, Jr., USA

187. Tong, K. N., Two-dimensional potential flow in a gravitational field with a known free stream, *Proc. second U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 603–606.

Method of analytic continuation is developed which determines the flow near a given known free streamline. This known streamline can be of arbitrary shape, defined by a real analytic function.

By first assuming the shape of the free streamline the order of solution is reversed. This inverse solution is mathematically simple but gives concise results. Since the general solution of many problems is not known, the method here developed is of interest. Author includes example of application of method.

J. DeYoung, USA

188. Blackaby, J. R., Low-speed investigation of the effects of angle of attack on the pressure recovery of a circular nose inlet with several lip shapes, *NACA TN* 3394, 30 pp., May 1955.

An investigation was made at a free-stream Mach number of 0.237 of the effects of lip bluntness and profile on the total-pressure recovery of a circular nose inlet in a ducted body of revolution at angles of attack up to 25°. A sharp inlet lip having a wedge angle of 7-1/2° was tested in addition to two circular-arc lips and two lips with elliptical profiles, all of which were formed within the 7-1/2° angle of the sharp lip.

From author's summary

189. Okabe, J., An approximate calculation of the flow of a viscous fluid past a body having a flat end, *Rep. Res. Inst. appl. Mech. Kyushu Univ.* **3,** 9, 45–50, Apr. 1954.

190. Cuming, H. G., The secondary flow in curved pipes, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2880, 17 pp., Feb. 1952, published 1955.

Paper deals with fully developed secondary flow of a viscous incompressible fluid in curved pipes of various cross sections. Power-series solution for secondary flow in curved elliptic pipe is given to first power of curvature. Effect of aspect ratio, defined ratio of semi-minor axis to semi-major axis, on intensity of secondary flow is calculated and discussed. Results indicate a diminution of this flow for both high and low values of aspect ratio.

Method of solution for rectangular cross section is indicated. Approximate solution for square section shows secondary flow is more intense in this case than for circular section.

Investigation of a particular distribution of wall suction yields result that suitable choice of suction almost entirely eliminates decrease of flux in curved circular pipes. R. W. Detra, USA

191. Herzig, H. Z., and Hansen, A. G., Visualization studies of secondary flows with applications to turbomachines, *Trans. ASME* **77,** 3, 249–266, Apr. 1955.

See AMR **7,** Rev. 1933.

192. DiPrima, R. C., Application of the Galerkin method to problems in hydrodynamic stability, *Quart. appl. Math.* **13,** 1, 55–62, Apr. 1955.

Author considers two fundamental problems: hydrodynamic stability of viscous flows between two rotating concentric cylinders and over concave surfaces. He starts from well-known differential equations and boundary conditions but tries to solve them by Galerkin's method, which seems to bring a new point of view in the treatment of these problems. In the case of the rotating cylinders, statements are made about the structure of the eigenvalue considered and its dependence on two parameters. Numerical results obtained are in satisfactory agreement with those of Tayler and Meksyn. Görtler's equations for marginal stability of three-dimensional disturbances for flows over concave surfaces are also solved by the Galerkin method. Computed results seem to confirm those of Görtler.

A study of the rate of convergence would be of some interest.

R. Albrecht, Germany

193. Clarion, C., Damped oscillations of rotation of a sphere in a viscous fluid (in French), *C. R. Acad. Sci. Paris* **240,** 21, 2049–2051, May 1955.

Some relationships similar to the ones previously derived for the translatory oscillations of a sphere are found applicable to the free movement of a sphere oscillating with respect to one of its diameters.

From author's summary by A. Balloffet, USA

194. Chandrasekhar, S., The character of the equilibrium of an incompressible fluid sphere of variable density and viscosity subject to radial acceleration, *Quart. J. Mech. appl. Math.* **8,** part I, 1–21, Mar. 1955.

This paper represents a theoretical treatment of a problem having applications in the area of geo- and astrophysics. The following statement of the nature of the analysis is taken from the author's summary.

"An incompressible fluid sphere, in which the density and the viscosity are functions of the distance r from the center only, is subject to a radial acceleration $-\gamma r$, where γ is a function of r, to determine the manner of initial development of an infinitesimal disturbance. By analyzing the disturbance in spherical harmonics, the mathematical problem is reduced to one in characteristic values in a fourth-order differential equation, and a variational principle characterizing the solution is enunciated. The particular case of a sphere of radius R and density ρ_1 embedded in a medium of a different density ρ_2 (but of the same kinematic viscosity ν) is considered in some detail; and it is shown that the character of the equilibrium depends on the sign of $\gamma_R(\rho_2 - \rho_1)$ and the magnitude of $\sigma = \gamma_R R^4/\nu^2$. If $\gamma_R(\rho_2 - \rho_1) > 0$, the situation is unstable and the mode of maximum instability is $l = 1$ for all $\sigma < 230$; for larger values of σ it shifts progressively to higher harmonics. In the case $\gamma_R(\rho_2 - \rho_1) < 0$, the results of both an exact calculation and an approximate calculation (based on the variational principle) are given and contrasted. In the case $\gamma_R(\rho_2 - \rho_1) < 0$ when the situation is stable, the manner of decay of the disturbance is briefly discussed in terms of an approximate theory only." M. J. Thompson, USA

195. Resek, R. B., Fluid conversion factors for pressure drop calculations, *Prod. Engng.* **25,** 6, 197–199, June 1954.

Compressible Flow, Gas Dynamics

(See also Revs. 215, 222, 226, 229, 231, 233, 262, 267, 321, 322, 329, 333)

196. **Ward, G. N., Linearized theory of steady high-speed flow,** New York, Cambridge University Press, 1955, xv + 243 pp. $6.

This subject has been variously surveyed in recent years (e.g., by Frankl and Karpovich, 1948; Oswatitsch, 1952; Ward in the "Modern developments. . .," 1953; Heaslet and Lomax in the "Princeton series," vol. 6, 1954). The present monograph, which devotes 100 pages to "General theory," 80 pages to the "Special methods" of sub- and supersonic wing theory including conical flow fields, and the remainder to "Slender-body theory," offers a highly original and unified account of the theory, giving the scalar-potential formulation side by side with the vectorial formulation and using the vectors of perturbation velocity and of perturbation mass flux concurrently.

In the first part, the assumptions underlying linearization are thoroughly discussed for irrotational *and* for rotational fields; the general solutions of the scalar and vector equations are developed for sub- and supersonic fields including distributed sources and vortexes; and uniqueness theorems for the irrotational flow past thin bodies are derived. Flow-reversal theorems and the reduction of the general solutions to a form directly applicable to thin bodies in irrotational flow conclude this part.

In the second part, the treatment of the subsonic thin-body flow is very brief, but the corresponding supersonic finite wing theory is rather fully developed (Evvard's method and its generalizations). Conical fields are treated in the form developed by Goldstein and the author in 1950, and a section of more than 20 pages on operational methods in supersonic flow will be welcome to many workers in the field.

In the third part the well-known results for axisymmetric flow past slender bodies are briefly reviewed, more general slender-body flows are then represented by vortex multiplets, and the accuracy of the slender body approximation is examined by methods due to the author (1949). After a section on aerodynamic forces and moments, applications to small-aspect-ratio wings and to winged bodies of revolution are sketched. Finally, bodies of revolution with broken meridian curves are treated (Lighthill) and the results applied to ducted bodies.

The bibliography quotes almost 200 references, of which less than one third is of British origin. The book is carefully written and proofread, and well printed (this reviewer noticed only a few insignificant slips). It is addressed to the research aerodynamicist, has not the character of a ready reference or textbook, and will reward only the attentive reader. G. Kuerti, USA

197. **Isay, W.-H., Treatment of compressible subsonic flow through axial and radial paddle gratings** (in German), *ZAMM* **35,** 1/2, 34–44, Jan./Feb. 1955.

"A method for the approximate calculation of the compressible subsonic flow through axial and radial paddle gratings with paddle profiles of any bend is shown, using essentially the results deduced by the author for incompressible flow through such gratings in two preceding articles."

Author uses incompressible velocity components obtained as results of integrated contributions of vorticity distributed along infinitely thin two-dimensional blade profiles as derived in previous papers. He inserts these in equations of compressible flow to obtain a solution in accordance with the Janzen-Rayleigh method. No convergency criterion has been arrived at. Since a set of formulas are given partly with their derivation omitted for reasons given and with no numerical examples worked out, reviewer finds it somewhat hard to assess practical value of the method, which presumably lends itself to processing in digital computing machines. J. R. Schnittger, Sweden

198. **Richter, H., The Chaplígin hodograph method in subsonic flow with circulation** (in German), *ZAMM* **35,** 1/2, 1–11, Jan./Feb. 1955.

Since the summarizing exposition of A. Busemann [*ZAMM* **17,** 73–79, 1937], further fundamental papers on Chaplígin's method were published which allow for circulation. From many points of view, the representations are lacking in complete rigor. The present paper is intended to close these gaps in a complete exposition by discussion of the mappings used. Especially investigated, is whether there can be a one-to-one correspondence between compressible and incompressible flow. By aid of the theory of functions of a complex variable, a simple method is deduced for the computation of the aerodynamic forces. The final formulas are analogous to that in the case of incompressible flow.

From author's summary by K. Stewartson, England

199. **Ehlers, F. E., On some solutions of the hodograph equation which yield transonic flows through a Laval nozzle,** *J. aero. Sci.* **22,** 2, 107–123, Feb. 1955.

The Tricomi equation is an approximate representative for irrotational compressible flow in the transonic region and in terms of hodograph variables. Its solution can be given in terms of hypergeometric functions. Various solutions representing channel flows are found having singularities at the sonic point. Depending on the order of the singularity, the following types of flows are found: Flows with sonic line concave to incoming flow, having finite curvature and such that acceleration along a streamline is positive; flows with sonic line concave to incoming flow, having zero curvature at the symmetrical streamline and such that acceleration along the axis is zero at the sonic point; flows in which the sonic line is straight and the acceleration along the streamlines vanishes at every point of the sonic line. Author also discusses nonsingular solutions that yield channel flows. The termination of the nozzles by the method of characteristics is described. H. G. Cohan, USA

200. **Kaye, J., Brown, G. A., Dieckmann, J. J., and Sziklas, E. A., Experimental velocity profiles for supersonic flow of air in a tube with and without heat transfer,** *Proc. second U.S. Nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., June 1955, 787–792.

Paper is one of a series on a continuing study of the mechanics of supersonic flow in round tubes. In the analysis of such a system, an important piece of information is the character of the boundary layer on the tube wall. The present report gives preliminary results which indicate little or no effect of heat transfer on velocity distribution. Comparison with work of others (flat plate) is made and appears satisfactory.

No doubt, future reports will present additional experimental information and analyze more completely the system under study.

D. L. Doughty, USA

201. **Rennemann, C., Jr., Minimum-drag bodies of revolution in a nonuniform supersonic flow field,** *NACA TN* 3369, 25 pp., Feb. 1955.

Extension of the Sears-Haack result is made by using linearized supersonic theory and considering flow interference effects such as arise from proximity of another body of revolution in the flow. Solution of an isoperimetric problem of the calculus of variations determines meridian contour for minimum wave drag, in the manner of von Kármán's Volta Congress paper, for bodies of

fixed volume and length. Result indicates negligible drag reduction over Sears-Haack value for uniform flow, and insignificant change of body shape; hence, shaping satellite bodies for favorable wave drag need not consider flow interference.

Whereas limitation to bodies pointed at both ends as well as neglect of friction and wake drag components limit the practical utility of the results, reviewer believes the value of author's contribution lies in demonstrating that for wave drag, unlike lift, linearized theory reveals no important consequences of flow interference. I. Michelson, USA

202. Johannesen, N. H., Experiments on supersonic flow past bodies of revolution with annular gaps of rectangular section, *Phil. Mag.* (7) **46,** 372, 31–39, Jan. 1955.

The supersonic flow past flat-nosed circular cylinders with annular gaps of rectangular section was investigated by schlieren photography and pressure measurements. The length of the gap was varied in small steps, from low values, where the gap formed a single dead-air region, to high values, where the flow in the gap consisted of two dead-air regions with an intermediate region of attached flow. In particular, the length of the gap for which the flow changed from the type with one to the type with two dead-air regions was determined. The experiments throw some light on the details of the flow in the dead-air regions, and it was found that the velocities inside these regions may be of considerable magnitude.

From author's summary by W. A. Mair, England

203. Probstein, R. F., and Bray, K. N. C., Hypersonic similarity and the tangent-cone approximation for unyawed bodies of revolution, *J. aero. Sci.* **22,** 1, 66–68, Jan. 1955.

Note in Readers' Forum.

204. Clarkson, M. H., A second-order theory for three-dimensional wings in supersonic flow, *Quart. J. Mech. appl. Math.* **7,** part 2, 203–221, June 1954.

Lighthill's method, giving approximations which are uniformly valid, is applied to the disturbance velocity potential ψ for the supersonic flow about a wing. Both ψ and x are developed into a power series in the thickness parameter θ with coefficients, which are functions of y, z, and an auxiliary variable u, equal to x in zero order. Substitution into the equation for compressible flow and the boundary conditions gives a set of linear equations, all, except the first, inhomogeneous. These can be solved successively by the Hadamard-Riesz method. The method is applied to the two-dimensional wedge; in the shock-wave case the inherent difficulties are overcome by simulating the contour as a limiting case of a suitable function $D(x, \alpha)$, which for $\alpha \to 0$ passes into the wedge. The shock-wave relations are obtained into second order. The Prandtl-Meyer flow is obtained by straightforward calculation. Finally, the method is applied to wing with straight leading edge, rolling at constant angular velocity. Application to a wing with supersonic leading edges is outlined. R. Timman, Holland

205. Martin, J. C., A vector study of linearized supersonic flow applications to nonplanar problems, *NACA Rep.* 1143, 34 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 3482.

206. Mirels, H., Laminar boundary layer behind shock advancing into stationary fluid, *NACA TN* 3401, 25 pp., Mar. 1955.

Problem is reduced, using the Howarth transformation, to the Blasius equation with a nonzero tangential velocity boundary condition at the wall in the coordinate system chosen. A perturbation solution is carried out with weak shocks, verifying that the Donaldson-Sullivan approach to this problem [AMR **3,** Rev. 330] is exact in this limit. A numerical solution is carried out for strong shocks. For both weak and strong shocks, boundary-layer profiles, skin friction, heat transfer, and recovery characteristics are shown. Two alternate formulations of the basic equations are developed. It is shown that the results are fairly close, even for finite shock strengths, to the classical Rayleigh problem of boundary-layer development on an infinite plate started impulsively. B. W. Augenstein, USA

207. Jones, C. W., On the propagation of shock waves in regions of non-uniform density, *Proc. roy. Soc. Lond.* **228,** 1172, 82–99, Feb. 1955.

Former solutions for intense explosions, terrestrial or stellar, assumed constant energy, which is incompatible with exact shock conditions. Author obtains a "similarity" solution in which density varies according to a power law. Approximate solutions for very strong shocks previously found by author are asymptotically correct for progressive waves with constant energy; the present solution for strong, but not very strong, shocks is a good approximation to constant energy flow and, in addition, estimates the variation of shock strength. A tabulation of pressure and speed for plane progressive waves in air is given for a constant shock strength of $s = 2, 5, 10, 50, \infty$, covering the period from the time when the shock passes a given point to a time about twice as long; the shock strength a is defined by $p_1 = p_0(1 + s)$, where p_0 is initial pressure of the gas at rest the varying density of this gas may be obtained by high temperature gradient, e.g., with an electric arc discharge. G. R. Graetzer, USA

208. Martin, M. H., The propagation of a plane shock into a quiet atmosphere. I, II, *Canad. J. Math.* **5,** 1, 37–49, 1953; **7,** 2, 284–288, 1955.

Wave Motion in Fluids

(See also Revs. 320, 344)

209. Goldman, O. G., Water hammer—Its cause, magnitude, prevention, Connecticut, Columbia Graphs, 1953, xii + 116 pp.

Author states that solution to any and all cases of water hammer is easy, simple, and direct. No complex diagrams or equations are required. Discussion of theory is followed by examples and nomographs. Design of surge chambers is given in some detail and is backed by 20 years' successful experience. Reviewer believes book will not appeal to those who follow the works of Rich and Parmakian. D. G. Huber, Canada

210. Biesel, F., and Le Mehaute, B., Theoretical study of the reflection of waves from different types of obstacles (in French), *Houille blanche* **10,** 2, 130–138, Mar./Apr. 1955.

For the propagation of gravity waves in a channel, authors assume that the reflection and transmission coefficients and phase changes for a general type of obstacle will determine the reflected and transmitted waves at a certain distance from the obstacle. Then, by using the two corresponding complex numbers, Kreisel's result [*Quart. appl. Math.* **7,** no. 1, 1949; AMR **3,** Rev. 291] is confirmed: The reflection and transmission coefficients for every obstacle, even for an antisymmetric one, do not depend on the sense of direction of the incident wave. Certain relationships between the coefficients are derived under additional hypotheses concerning obstacles (isolated or in sets). The ratio of the amplitude between two obstacles to that of the inci-

dent wave is plotted versus the ratio of the distance between these obstacles to the wave length. W. S. Jardetzky, USA

211. **Bartels, R. C. F., and Downing, A. C., Jr., On surface waves generated by travelling disturbances with circular symmetry,** *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 607–615.

This paper deals with an old problem using methods which provide ". . . mathematical rigor which could not be hoped for in any of the previous presentations." Kelvin's problem—the linearized problem of surface waves produced by a pressure distribution moving at constant velocity on the surface of infinitely deep water—is formulated in terms of a singular integrodifferential equation. From this, the amplitude of the wave can be obtained directly in terms of the pressure distribution of the disturbance and the condition that the amplitude vanishes infinitely ahead of and at the sides of the disturbance. Solution for the predominant part of the wave is obtained by aid of the Abelian theorems for the complex inversion integral in the theory of Laplace transforms. The method used is not restricted to the special case of circular disturbances. R. A. Burton, USA

212. **Gibson, W. L., and Shelson, W., An experimental and analytical investigation of a differential surge tank installation,** ASME Ann. Meet., New York, N. Y., Dec. 1954. Pap. 54—A-138, 21 pp.

Tests were carried out at AGUASABON Generating Station with 2X22500-kw vertical shaft generators, and Francis turbines. The surge shaft is of the "differential" (Johnson) type. The water levels and the dynamic pressures at different points of the surge shaft, of the pressure tunnel, and of the pressure pipeline, the water discharge, and the turbine gate position were measured. Surges and water hammer were recorded for full load rejection and for partial picking up of the load. The results were compared with computed values of surges and with water-hammer analysis on digital computer. The calculated results agreed closely with those determined experimentally. It is the first time that experiments on a large tank were proceeded with on such a large scale, and results compared to detailed calculations.
C. Jaeger, England

213. **Ghatage, V. M., Liquid filled shock absorbers,** *J. Instn. Engrs., India* **35,** 1, 25–29, Sept. 1954.

A hydraulic shock absorber suitable for use with airplane landing gear is described. The absorber is assumed to be a piston and piston rod contained in a cylinder. A fluid contained in the cylinder is forced to flow through orifices in the piston head when there is relative motion between the piston and cylinder. Because of the volume occupied by the piston rod, the liquid is compressed as the piston is forced into the cylinder. Calculations are given which determine the elastic energy absorbed by the liquid and the energy dissipated by flow through the orifices and by friction. The effects of spring-loaded valves in the orifices are also considered. I. Vigness, USA

214. **Macagno, E.-O., Wave action in a flume containing a submerged culvert** (in French), *Houille blanche* **9,** 1, 10–37, Jan./-Feb. 1954.

A submerged passageway of adjustable length and height is created in a wave tank by immersing in it a rectangular box of breadth equal to the channel width. The reflected and transmitted wave heights and their phase differences with respect to the incident wave are investigated both theoretically and experimentally, along with the energy loss. The theory, which includes the cases of both linear and quadratic friction in the passageway, is approximate and successfully predicts the trends and upper and lower limits of the experimental results. The effect of variation of incident wave amplitude is found to be extremely small. For a given passageway the transmitted wave height increases with increasing incident wave period, while its phase difference decreases. Comparisons are made with available results on waves in the presence of an immersed vertical plate, i.e., a passageway of zero length. G. Kulin, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 97, 200, 206, 232, 265, 293, 294, 295, 296, 326)

215. **Schlichting, H., Boundary layer theory,** New York, McGraw-Hill Book Co., Inc.; London, Pergamon Press Ltd.; Karlsruhe, Verlag G. Braun, 1955, xx + 535 pp. $15.

This is the English-language edition of the book published in 1951 [AMR **5,** Rev. 194], translated by Prof. J. Kestin. It is not simply a literal translation of the German edition, since two chapters have been completely rewritten and smaller additions have been made elsewhere. The quite inadequate index of the original book, to which the reviewer once objected, has been replaced by a much more complete one. The translation seems to have rendered the German original accurately into graceful and readable English.

The two rewritten chapters are those on compressible boundary layers and on turbulent boundary layers in pressure gradients. The first of these subjects is one of rapid progress these days, and the revision has made it possible to report on much of this recent work. The material on shock-wave boundary-layer interaction has been enlarged and now includes many of the results of H. W. Liepmann and his associates. The new chapter on turbulent layers is also more nearly up to date, including as it does the von Doenhoff-Tetervin and Garner procedures, previously only mentioned in an addendum, and Truckenbrodt's recent work. Throughout the volume, additional references to literature and even new subsections have been inserted.

The German edition has already proved useful to teachers, research workers, and engineers. The new version will undoubtedly be found even more valuable to English and American users, especially because the author has taken the trouble to add so much new material. W. R. Sears, USA

216. **Glauert, M. B., and Lighthill, M. J., The axisymmetric boundary layer on a long thin cylinder,** *Proc. roy. Soc. Lond.* (*A*) **230,** 1181, 188–203, June 1955.

In this competently written paper the authors investigate the accuracy of a Pohlhausen method of determination of the laminar boundary layer on the outside of a semi-infinite circular cylinder, the flow outside the boundary layer being assumed to be everywhere parallel to the cylinder axis and uniform. The form of velocity profile used in the Pohlhausen method is simply $u = (U/\alpha)\ln(r/a)$ for values of the radial distance r between a (radius of cylinder) and that value at which u becomes equal to the free-stream speed U, the parameter α being determined in the usual way from the momentum integral equation. Near the front of the cylinder (where the assumed profile is correct to $0 = [(r-a)/a]^3$), the Pohlhausen method is checked against the series solution found by Seban and Bond [AMR **5,** Rev. 1161], and far downstream it is checked against an asymptotic series solution obtained by the authors. The agreement is good enough in both places to provide confidence in use of the results from the Pohlhausen method in the intermediate range, where the boundary-layer thickness is neither small nor large compared with the cylinder radius. G. K. Batchelor, England

217. Wadhwa, Y. D., Boundary layer for a parabolic cylinder, *ZAMM* **35,** 1/2, 67–69, Jan./Feb. 1955.

Following precedents, author in substance guesses at a suitable approximate solution and demonstrates that the external force field necessary to keep the flow steady is small. The mode of approach is weak in that it does not yield precise tangible results. The results strengthen, however, our confidence in the accepted notions regarding laminar flows of viscous fluids.

M. M. Munk, USA

218. Iglisch, R., Elementary proof for the uniqueness of the flow in the laminar boundary layer with the potential flow $U = u_1 x^m$ with $m \geqq 0$ with suction or injection (in German), *ZAMM* **34,** 12, 441–443, Dec. 1954.

Author proves the uniqueness of the problem reviewed in AMR **6,** Rev. 3821. F. W. Riegels, Germany

219. Mager, A., Incompressible non-meridional boundary layer flow on bodies of revolution, *U. S. nav. Ord. Test. Sta., Inyokern, Rep.* 3366, 56 pp., Sept. 1954.

A method is described for computing the incompressible boundary-layer flow on a body of revolution at a small angle of attack or rotating with a small angular velocity about some axis in space.

The method is applicable to both laminar and turbulent three-dimensional boundary layers, and, in the former case, two simple examples are evaluated to illustrate the procedure. Some experimental verification has been obtained in the turbulent case.

A. R. Mitchell, Scotland

220. Spence, D. A., and Randall, D. G., The influence of surface waves on the stability of a laminar boundary layer with uniform suction, *Aero. Res. Counc. Lond. curr. Pap.* no. 161, 19 pp., 6 figs., Mar. 1953, published 1954.

Authors estimate the destabilizing effect of small sinusoidal waves on porous surfaces used with boundary-layer suction by calculating the additional suction required to preserve the same level of laminar stability as would occur if the surfaces were flat. The basic (incompressible) flow is that on a porous plane having sufficient suction to yield unchanging boundary-layer thickness and shape in the stream direction. The flow over each of the various wavy surfaces exhibits the property that thickness and shape are the same at corresponding points in successive waves. Suction quantities for maintaining laminar stability are calculated from the condition that the displacement-thickness Reynolds number should not at any point be greater than critical.

Curves giving the additional suction required to preserve a stable laminar layer over the wavy surfaces are presented which cover ranges of Reynolds number based on wave length from 6×10^3 to 10^6, amplitude-to-wave length ratio from 10^{-4} to 10^{-2}, and suction velocity-to-mainstream velocity ratio from 1×10^{-4} to 5×10^{-3} In cases of practical interest, the additional suction required is of the order of 10% or less.

Authors state that although the potential instability introduced by the waves themselves has not been considered in the calculations, the results should represent an upper limit for the increase in suction necessary to preserve stability, because sufficient suction is always applied to damp out all oscillations, whatever their source. H. A. Stine, USA

221. Rothfus, R. R., and Monrad, C. C., Correlation of turbulent velocities for tubes and parallel plates, *Indust. Engng. Chem.* **47,** 6, 1144–1149, June 1955.

The applicable range of the logarithmic velocity distribution in a smooth pipe has been extended by an empirical correction. The dimensionless velocity $u(\tau_0/\rho)^{1/2}$ is multiplied by the ratio of the mean velocity to the centerline velocity V/u_m. The dimensionless length term $(\tau_0/\rho)^{1/2}(y/\nu)$ is multiplied by the ratio of the centerline velocity to the mean velocity u_m/V. The data from numerous experiments are graphically presented to show the single functional relationship down to a Reynolds number of 3000. Data are then graphically presented in order to demonstrate that the same functional relationship is applicable to flow between flat plates.

The data from numerous experiments are graphically presented relating V/u_m and the Reynolds number for both flow between flat plates and in a circular pipe.

In shear stress calculations for turbulent flow between flat plates, a Reynolds number equal to $V(2R)/\nu$ is proposed in lieu of the usual $V(4R)/\nu$. Here R is the hydraulic radius.

M. R. Carstens, USA

222. Laurence, J. C., Intensity, scale, and spectra of turbulence in mixing region of free subsonic jet, *NACA TN* 3561, 58 pp., Sept. 1955.

Hot-wire anemometer measurements of the intensity of turbulence, the longitudinal and lateral scales, and the spectra of turbulence were made in a 3.5-in.-diam free jet at exit Mach numbers between 0.2 and 0.7 and Reynolds numbers (based on jet radius) between 37,500 and 350,000.

The results of these measurements show that (1) the intensity of turbulence, expressed as a per cent of the core velocity, is a maximum at a distance of approximately 1 jet radius from the centerline and decreases with increasing Mach and/or Reynolds number, and (2) the lateral and longitudinal scales of turbulence are nearly independent of Mach and/or Reynolds number and vary proportionally with distance from the jet nozzle. The lateral scale is much smaller than the longitudinal and does not vary with distance from the centerline of the jet, while the longitudinal scale is a maximum at a distance from the centerline of about 0.7 to 0.8 of the jet radius. From author's summary

223. Favre, A., Gaviglio, J., and Dumas, R., Space-time correlation obtained with band-filters behind a turbulence grid (in French), *Rech. aéro.* no. 40, 7–14, July/Aug. 1954.

Space-time correlation data are presented that were obtained in a turbulent flow produced by a 1-in. mesh grid. Most data presented were obtained 40 mesh lengths behind grid. The longitudinal (u') component of the velocity fluctuation was measured. The correlation between the two signals obtained at different locations and having relative delay was measured extensively. In order to get clues about anisotropy at low wave numbers, the same measurements were repeated also with high- and low-pass filters. "Taylor's hypotheses" concerning interchangeability of time and space coordinates are verified by the data presented.

L. S. G. Kovasznay, USA

224. Krzywoblocki, M. Z., On turbulence in rarefied gases, *Proc. second, U. S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., 1955, 677–685.

Grad's representation of equations of motion, continuity, and energy is used to describe turbulent vector fields of a flow in the realm of rarefied gases. The method of space Fourier spectrum is applied to show that the field variables (velocity, density, pressure, and temperature fields) separate into a few distinct groups: one corresponding to eddy turbulence, the other associated with fluctuating acoustical waves, etc. From that standpoint the result is analogous to that one obtained by previous authors using simplified Navier-Stokes equations. Derivations of equations of motion for spectral tensors closes the paper.

From author's summary by W. Squire, USA

225. **Blackadar, A. K., Extension of the laws of thermodynamics to turbulent systems,** *J. Meteor.* **12,** 2, 165–175. Apr. 1955.

Author presents equations expressing rates of interconversion among kinetic energy of mean motion, eddy energy, and mean internal energy of an infinitesimal particle of compressible fluid undergoing turbulent motion. These equations are derivable from continuity and momentum equations and First Law expression for an infinitesimal particle of fluid. The rate at which eddy energy is transferred to the fluid particle may be identified with the negative divergence of a vector appropriately called eddy-energy flux.

Author next considers sign of rate of transformation of mean motion kinetic energy to eddy energy, citing measurements in the atmosphere which yielded both positive and negative values. He demonstrates that this transformation is not irreversible in the sense of the Second Law.

Analogous to ordinary thermodynamics, author formulates laws of eddy thermodynamics: an eddy equation of state, and a first and Second Law, the latter involving an eddy entropy function. By the Second Law, eddy entropy tends to increase in the absence of conversion of eddy energy to internal energy and in the absence of molecular diffusion. A further consequence, although not a necessary one, is that the eddy-energy flux takes place in the direction of decreasing eddy energy. There is some experimental confirmation of this.

Author finally interprets eddy entropy in terms of the frequency distribution of eddy velocities, analogous to the statistical view of ordinary entropy as a measure of the probability of a molecular velocity distribution.

Engineering applicability of material presented in this paper seems extremely remote. Abstruseness of reasoning and lack of table of nomenclature make material unnecessarily difficult to understand. A. W. Gessner, Germany

Aerodynamics of Flight; Wind Forces

(See also Revs. 126, 150, 188, 201, 204, 215, 246, 248, 266, 327)

226. **Dubs, F., Aerodynamics of pure subsonic flow [Aerodynamik der reinen Unterschallströmung],** Basel/Stuttgart, Berlag Birkhäuser, 1954, 225 pp., 178 figs. Sw.Fr. 22.

Author's purpose is to present an elementary but correct exposition of the fundamentals of technical aerodynamics. Fourteen chapters without mathematical development deal successively with the following matter: The atmosphere, laws of fluid motion, laminar and turbulent flow, flow pictures, the boundary layer, means for preventing boundary-layer separation, subsonic wind tunnels, the magnus effect, the airfoil, profile form and polar diagram, the residual drag, the interference drag, aerodynamic brakes, the resulting aircraft polar diagram.

Book will adequately fill the gap between the more scientific textbooks on classical aerodynamics and the popular pamphlets. P. Schwaar, France

227. **Diprose, K. V., Analogue computing in aeronautics,** *J. roy. aero. Soc.* **59,** 535, 479–493, July 1955.

Paper deals with use of analog computers for numerical calculations of aeronautical problems. "Simulators," i.e., sets of electronic units each making an elementary or differential operation, are discussed with respect to interconnection of units to solve mathematical equations and accuracy of results (which is claimed to reach 0.1% for linear operations and 1% for nonlinear ones).

The electrolytic tank and network analyzer, based on the formal identity of equations of electrical and other physical phenomena, are later discussed with special regard to harmonic and biharmonic functions. Comparison is made with analog and digital computers, with application to a special problem of mechanics, and some applications to aeronautics are indicated.

Paper closes with consideration of further developments and requirements of analog computers. G. Evangelisti, Italy

228. **Schmidt, R., and Klages, P., Model methods in aeronautics** (in German), *Z. Flugwiss.* **3,** 7, 169–204, July 1955.

Paper deals with the various techniques of model testing in aviation. Beginning with the various techniques of model testing most commonly used in wind tunnels and its conditions regarding the law of similarity which have to be observed, the technical equipment is briefly discussed, and the accuracy and reliability that can be expected from measurements are given. A further description is given of the towing technique and free-flight measurements of various types. The type of problem, the equipment required for the experiments, the sources of disturbance and error which impair the reliability are discussed in view of available experience and possible improvement. Then the characteristics of the various techniques regarding type of problem, range of applicability, technical requirements, and reliability of measurements are compared with the wind tunnel. The conclusion is that the towing technique with carrier slide or carrier airplane offers the greatest possibilities for substituting large-size wind tunnels. Finally, technical details are given of various projects dealing with a piloted supersonic carrier airplane, a supersonic carrier slide, and of the equipment required for measuring aerodynamic forces. From authors' summary

229. **Brown, C. E., and Michael, W. H., Jr., Effect of leading-edge separation on the lift of a delta wing,** *J. aero. Sci.* **21,** 10, 690–694, 706, Oct. 1954.

Paper presents a solution of the two-dimensional Laplace equation with boundary conditions to simulate leading-edge separation on a delta wing. The Laplace equation arises from the assumptions that the body is slender and that the velocity may be represented by a perturbation potential. The separation at the leading edge is represented by two concentrated vortexes and two feeding vortex sheets. Pressure distribution and lift are determined from the solution. Comparison with experiment indicates that the lift is overestimated. J. P. Craven, USA

230. **Haskell, R. N., Hosek, J. J., and Johnson, W. S., Jr., Equations for the chordwise center of pressure for the basic twist distributions on triangular wings having supersonic leading and trailing edges,** *J. aero. Sci.* **22,** 4, p. 274, Apr. 1954.

Note in Readers' Forum.

231. **Chapman, D. R., Reduction of profile drag at supersonic velocities by the use of airfoil sections having a blunt trailing edge,** *NACA TN* 3503, 29 pp., Sept. 1955.

A preliminary theoretical and experimental investigation has been made of the supersonic aerodynamic characteristics of blunt trailing-edge airfoils. Calculations of the drag of a family of airfoils with finite trailing-edge thickness are presented for various values of the base pressure. Theoretical expressions for the lift, pitching moment, and maximum lift-drag ratio are developed using the Busemann second-order theory for two-dimensional supersonic flow. In order to compare the theoretical estimates with experimental data, measurements were taken of the lift and drag on wings of various airfoil sections at Mach numbers of 1.5 and 2.0 and at Reynolds numbers varying from 0.2 to 1.2 million. Rectangular planforms with an aspect ratio of 4 and a thickness ratio of either 10 or 9.1% were used throughout the experiments.

The experimental findings are in accord with the theoretical considerations in indicating a decrease in profile drag and an increase in lift-curve slope for properly designed airfoils with moderately blunt trailing edges. As compared to a 10-percent-thick double-wedge airfoil of equal section modulus, reductions in profile drag of 15 to 31% have been measured in the Mach number and Reynolds number range investigated. As compared to sharp trailing-edge airfoils in general, the experimental results showed an increase in lift-curve slope of 17% for a 10%-thick airfoil with the maximum thickness located at the trailing edge.

The minimum drag of blunt trailing-edge airfoils depends to a large extent on the profile shape near the trailing edge. As a result, the improper design of a blunt trailing-edge airfoil may lead to an increase in minimum drag coefficient. It is shown that, in such cases, the maximum lift-drag ratio is not necessarily reduced since the lift-curve slope may be sufficiently improved to more than compensate for a small increase in minimum drag.

The trends to be followed in designing airfoils with lower drag and improved structural characteristics are briefly discussed in light of the present results and existing knowledge about base pressure in two-dimensional flow. It is concluded that in many cases the combined structural and aerodynamic advantages offered by blunt trailing-edge airfoils are sufficient to warrant their use as a practical wing section.

From author's summary

232. Dunning, R. W., and Ulmann, E. F., Effects of sweep and angle of attack on boundary-layer transition on wings at Mach number 4.04, *NACA TN* 3473, 31 pp., Aug. 1955.

Although subject to the several uncertainties of any study of transition in a turbulent wind tunnel, the results of this work show two trends which are of considerable interest and importance. First, it appears that it is inherently more difficult to maintain laminar flow on swept wings than on rectangular wings. Second, the leading-edge radius of the wing is a factor of major importance at high supersonic speeds; longer runs of laminar flow were achieved by increasing the leading-edge radius, especially for the unswept wings. J. V. Becker, USA

233. Nelson, W. H., and McDevitt, J. B., The transonic characteristics of 22 rectangular, symmetrical wing models of varying aspect ratio and thickness, *NACA TN* 3501, 109 pp., June 1955.

An investigation to determine the aerodynamic characteristics of a series of thin, rectangular wings was conducted in the Ames 16-ft high-speed wind tunnel, utilizing the transonic-bump technique over a Mach number range from 0.40 to 1.10, corresponding to a Reynolds number range from 1.25 to 2.05 million. The lift, drag, and pitching-moment data are presented for wings having aspect ratios of 6, 4, 3, 2, 1.5, 1, and 0.5, and NACA 63AOXX sections with thickness-to-chord ratios of 10, 8, 6, 4, and 2%.

From authors' summary

234. Henderson, A., Jr., and Goodwin, J. M., The zero-lift wave drag of a particular family of unswept, tapered wings with linearly varying thickness ratio, *NACA TN* 3418, 28 pp., May 1955.

On the basis of linear theory, the zero-lift wave drag of a particular family of unswept tapered wings with linearly varying thickness ratio and symmetrical parabolic-arc sections has been calculated. The case of the wing with a given root-thickness ratio is given primary consideration with the view toward its use for missiles with all-movable fins, where the root thickness must be large enough to allow for a rigid attachment to the trunnion and controlling mechanism. By comparing the drag for these wings with that for a corresponding constant-thickness-ratio wing with rhombic sections, it is found that the variable-thickness-ratio wings can be used to advantage with no serious structural penalties if the wings are assumed to have the same given root-thickness ratio or the same internal volume.

From authors' summary

235. Lee, G. H., The aerodynamic and aeroelastic characteristics of the crescent wing, *J. roy. aero. Soc.* **59,** 529, 37–44, Jan. 1955.

236. Beane, B. J., Notes on the variation of drag with Mach number of a Busemann biplane, *Douglas Aircr. Co. Rep.* SM-18737, 6 pp., Jan. 1955.

237. Woods, L. C., On unsteady flow through a cascade of aerofoils, *Proc. roy. Soc. Lond.* (*A*) **228,** 1172, 50–65, Feb. 1955.

The basic theory of the unsteady flow of an incompressible fluid through a cascade of thin airfoils is developed. Expressions for the pressure distribution, lift, and moment on an airfoil of the cascade are obtained. A simple formula for the growth of lift due to a sharp-edged gust, which is a generalization of Wagner's well-known result for a single airfoil, is derived. The corresponding generalization of Theodorsen's function for a sinusoidal gust is also given.

From author's summary by J. T. Stuart, England

238. Batson, A. S., Measurement of lift, pitching moment and hinge moment on a two-dimensional RAE 102 aerofoil, *Aero. Res. Counc. Lond. curr. Pap.* 191, 29 pp., Nov. 1953, published 1955.

Charts in previous report [*Rep. Mem.* 2730] for estimating two-dimensional control derivatives were based mainly on data for airfoils of 15% thickness. Supplementary tests have been carried out on a two-dimensional 10% thick RAE 102 airfoil with 20% and 40% plain round-nosed control surfaces. Lift, pitching moment, and hinge moment were determined from balance measurements and from integrated pressure distributions at one section. In most cases, consistent coefficients were obtained by the two methods.

Particular care was taken in observing or fixing with wires the positions of boundary-layer transition on both surfaces of the airfoil. The experimental derivatives varied smoothly with position of transition and were in fair agreement with the general charts of *Rep. Mem.* 2730. From author's summary

239. Pappas, C. E., and Kunen, A. E., An investigation of the aerodynamics of sharp leading-edge swept wings at low speeds, *J. aero. Sci.* **21,** 10, 649–658, Oct. 1954.

Problem of leading-edge separation from sharp leading edges of swept wings is attacked by considering flow to contain swept-free vortex originating at point along edge. Origin and sweep angle of vortex line are determined from experimental data. Analysis is made of two-dimensional potential flow on streamwise airfoil including effect of free vortex. Kutta condition applied at leading and trailing edges is used to determine strength of free vortex and circulation around airfoil. Good agreement is shown with experimental section lift on one particular wing for one test condition.

This analysis, which at present is semiempirical, provides interesting contrast to papers of Brown and Michael [title source, Oct. 1954], Adams [op. cit., June 1953] and Legendre [*Rech. aéro.*, Nov.-Dec. 1952; AMR **6,** Rev. 3506] which deal with same phenomenon entirely theoretically on basis of slender-wing theory, and focus attention on two-dimensional flow in wing planes transverse to free stream, but also employ Kutta condition at leading edge. A. H. Flax, USA

240. **Lange, J., Mathematics of airplane shape** (in Polish), *Techn. Lotn.* **9**, 5, 128–133, Sept./Oct. 1954.

A translation of the paper, "Conics as applied to mathematical lofting," by R. Morrison [*Aircr. Engng.*, Feb. 1948].

M. Z. Krzywoblocki, USA

241. **Cahill, J. F., Underwood, W. J., Nuber, R. J., and Cheesman, G. A., Aerodynamic forces and loadings on symmetrical circular-arc airfoils with plain leading-edge and plain trailing-edge flaps,** *NACA Rep.* 1146, 38 pp., 1953.

A two-dimensional wind-tunnel investigation has been made of 6- and 10%-thick symmetrical circular-arc airfoil sections equipped with 0.15-chord plain leading-edge flaps and 0.20-chord plain trailing-edge flaps. The tests consisted of measurements of the aerodynamic forces and surface pressures at low Mach numbers (about 0.15) and several Reynolds numbers (0.7×10^6 to 18×10^6 based on the airfoil chord). A generalized method is developed that permits the determination of the chordwise pressure distribution over sharp-edge airfoils with plain leading- and trailing-edge flaps of arbitrary size and deflection.

From authors' summary

242. **Prosnak, W., Calculation of propeller aerodynamic characteristics** (in Polish), *Techn. Lotn.* **9**, 5, 136–145, Sept./Oct. 1954.

This is a résumé of the method of calculation of propeller aerodynamic characteristics proposed by the late Professor C. Witoszynski [*Proc. Inst. Aerodyn. Warsaw*, no. 8, 1949].

M. Z. Krzywoblocki, USA

243. **Fedyaevskiĭ, K. K., and Belotserkovskiĭ, S. M., Aerodynamic forces affecting ground installations in squalls** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 6, 13–24, June 1954.

244. **Martin, J. E., and Hoy, W. W., An application of the Buffon Needle problem to the determination of the probability of obtaining a free flight arrested landing in carrier landings,** *J. aero. Sci.* **22**, 1, 68–69, Jan. 1955.

Note in Readers' Forum.

245. **Bleviss, Z. O., Theoretical analysis of light plane landing and take-off accidents due to encountering the wakes of large airplanes,** *Douglas Aircr. Co. Rep.* SM-18647, 42 pp., 25 figs., Dec. 1954.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 29, 235, 345)

246. **Templeton, H., Massbalancing of aircraft control surfaces** (Aero. Monographs 4, published under authority of Royal Aero. Soc.), London, Chapman & Hall, Ltd., 1954, x + 241 pp. 35s.

Written with needs of the design engineer and aeronautical research worker in view, this book consists principally of an account of thirty years of painstaking British research on the problem of control-surface flutter, with emphasis on its elimination by mass balancing. Author defines limiting mass-balance condition of a control as one where "stability at all air speeds is first achieved . . ., the cross inertia concerned being that which is most significant in the type of flutter considered." He concentrates on how this condition is attained through design criteria, theoretical analysis, flutter model experiments, full-scale ground-resonance and flight tests, etc. Although lucid and thorough within its scope, the treatment is limited to conventional trailing-edge controls on lifting surfaces of relatively large aspect ratio and small sweep, flying at subcritical Mach numbers. Author makes the point that there is little reliable information on control-surface flutter outside these limitations.

Part I deals with basic principles of mass balancing, with chapters on influence of cross inertias in coupled free vibrations of lifting surfaces, mass-balance terminology, and flutter analysis of simple binary systems. Part II on applications of mass balancing contains chapters describing significant past research projects in Britain (divided into sections on aileron, elevator, rudder, and tab flutter), effects of important governing parameters, design criteria, practical mass-balancing procedure, and types of balance systems. Part III is a brief prognostication of future developments and discussion of limitations and alternatives to mass balancing. Appendixes cover certain details, notably two-dimensional aerodynamic theory, tab flutter, and an ingenious graphical technique for binary flutter calculation.

Author is prepared for his task by extensive experience, and his physical explanations are outstandingly clear. Reviewer feels the only serious flaw is a tendency to overgeneralize in drawing conclusions from limited data, so that an incautious reader, concerned with modern high-performance aircraft, may be given unwarranted confidence in principles which are fully proved only for subcritical flight speeds; e.g., "General superiority in respect of flutter prevention" at high speeds is ascribed to a type of actuator system which could often present insurmountable mechanical design difficulties. Book's restriction to British work on mass balancing is not regarded as a defect. Good selected bibliography is given.

H. Ashley, USA

247. **Press, H., and Houbolt, J. C., Some applications of generalized harmonic analysis to gust loads on airplanes,** *J. aero. Sci.* **22**, 1, 17–26, 60, Jan. 1955.

Paper contains several significant examples illustrating the adequacy of the generalized harmonic analysis to the gust load problem. The effects on gust loads of center of gravity position, short period damping, and wing bending flexibility are calculated and shown to agree rather well with experiments. Reviewer believes that these applications are particularly significant because, without the statistical arguments, the experimental results are probably hard to explain.

Tukey's methods for estimating spectra from measurements and for establishing the reliability of such estimates are described. Available measurements of atmospheric turbulences are given.

Y. C. Fung, USA

248. **Tapscott, R. J., and Gustafson, F. B., Helicopter blade flapping,** *Aero. Engng. Rev.* **14**, 9, 46–51, Sept. 1955.

Theoretical and experimental studies on blade-fuselage clearance for higher performance, higher speed helicopters, giving a detailed examination for tip-speed ratios approximately equal to 0.3.

From authors' summary

249. **Legendre, R., A simplified method of calculating the aerodynamic damping of compressor blades** (in French), *Rech. aéro.* no. 37, 3–10, Jan./Feb. 1954.

An outline is given of the theory and calculations needed to evaluate the aerodynamic damping of axial compressor blades. The flow is taken to be irrotational and two-dimensional, and the blades are taken as flat plates. Flexural vibrations only are considered. Adjacent blades are assumed to be in anti-phase, and thus any blade interaction is ignored. The flow field is transformed conformally, using Jacobian elliptic functions. An expression is given for the perturbation potential due to the blade

vibration, and it is shown that this can be expressed in terms of elliptic integrals.

The influence of the vortexes given off from the trailing edge of the blade is considered, and it is shown that the intensity of the free vortexes is independent of the time. No numerical results are given. Author claims that, although the calculations are complicated, this solution using elliptic integrals may be more convenient than that given by other methods.

A. W. Babister, Scotland

Propellers, Fans, Turbines, Pumps, etc.s

(See also Revs. 185, 191, 212, 242, 249, 283, 304, 310, 317, 319, 330, 332, 342)

250. Seibold, W., Approximation calculation of ducted propellers, *Z. Flugwiss.* **3,** 5, 130–134, May 1955.

The momentum theory based on the work of Rankine and Froude is used to calculate the thrust and efficiency of ducted propellers in the case when the static pressure in the slipstream is the same as in the undisturbed stream. A comparison with a conventional propeller shows that the ducted propeller at low speeds definitely has a higher efficiency than the conventional one.

E. Petersohn, Sweden

251. Krajewski, B., Calculation of characteristics of multistage axial compressors (in Polish), *Techn. Lotn.* **9,** 1, 17–20, Jan./Feb. 1954.

A résumé of the paper by F. Salzman ["Über die Druck—Volumen-Kennlinie der vielstufigen Ascialgebläsen," *Schweiz. Bauztg.* 1943]. M. Z. Krzywoblocki, USA

252. Huppert, M. C., Approximate method for determining equilibrium operation of compressor component of turbojet engine, *NACA TN* 3517, 22 pp., July 1955.

A method is presented for estimating the equilibrium operating line for a compressor as a component part of a turbojet engine. The performance characteristics of the combustor, turbine, and jet nozzle are treated in a simplified manner, so that the suitability of a given compressor for jet-engine application may be determined. The need for compressor-discharge bleed, a variable-area jet nozzle, or both, to obtain satisfactory engine acceleration may be estimated from the position of the equilibrium operating line and the compressor surge line.

Charts are presented that may be used to locate the equilibrium operating line on the performance map of the compressor component of a turbojet engine operating at sea-level static conditions.

A comparison of predicted and measured equilibrium operating conditions in terms of compressor pressure ratio and equivalent weight flow indicates satisfactory agreement.

From author's summary

253. Emmons, H. W., Pearson, C. E., and Grant, H. P., Compressor surge and stall propagation, *Trans. ASME* **77,** 4, 455–469, May 1955.

See AMR 7, Rev. 2204.

254. Anderson, H. H., Modern developments in the use of large single-entry centrifugal pumps, *Inst. mech. Engrs. Proc.* **169,** 6, 22 pp., 1955.

In parallel with the electric motor and the steam turbine, which provide suitable high-speed power, the centrifugal pump has been developed to a high degree of reliability and efficiency. This paper describes a recent step in this development, namely, the research, manufacture and adoption of single-entry pumps, combined with their driving mechanisms, for medium and large power duties.

From author's summary

255. Andrews, S. J., Tests related to the effect of profile shape and camber-line on compressor cascade performance, *Aero. Res. Counc. Lond. Rep. Mem.* 2743, 23 pp., Oct. 1949, published 1955.

Cascade tests have been made to obtain information on the related questions of whether simpler sections than the normal airfoil C4 can be used without loss of efficiency, and whether a particular section should be constructed on a circular-arc or a parabolic-arc camber line. Of the large possible number of simple shapes, three only were chosen for comparison with the airfoil. They were a flat plate with rounded leading and trailing edges, a flat plate with sharpened leading and trailing edges, and an approximately biconvex shape. A representative cascade shape was chosen (blade inlet angle 55°, outlet angle 30°, and pitch/chord ratio 0.75) and four cascades with the four sections mentioned above mounted on circular-arc camber lines were made up. In addition, to provide data on the relative advantage of circular-arc and parabolic-arc camber line, two cascades were made up on parabolic arcs.

The main conclusions to be drawn are that the approximately biconvex profile, which is a very simple shape to make, is superior to the airfoil at Mach numbers above 0.75, and that the circular-arc camber line is on the whole superior to the parabolic arc. The "plate" blades with blunt leading and trailing edges are poor in performance, but the "plate with sharpened edges" is reasonably good. It is suggested that very thin blades of the plate type may have certain applications. From author's summary

256. Banerjee, D., Stage performance study of axial compressor, *J. Instn. Engrs., India* **35,** 1, 93–100, Sept. 1954.

This paper is divided into three sections. The first section deals with the theoretical method of obtaining the stage characteristics; the second is devoted to the testing and analysis of test results of the three-stage axial compressor; and in the third section a brief outline is given of the methods of obtaining the over-all characteristics. From author's summary

257. Mei, A. J., Design and operation of small canned motor pumps, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-120, 12 pp.

258. Boon, E. F., Some fundamentals about pumps (in Dutch), *Ingenieur* **67,** 19, 27–31, May 1955.

The basic equations of pumps operating according to the positive displacement, the impulse, and the viscosity principle are explained. From author's summary

Flow and Flight Test Techniques

(See also Revs. 171, 182, 202, 207, 215, 233, 241, 318, 321)

259. Jung, R., Mean value error in the simplified estimation of average flow determined from several individual measurements (in German), *Brennstoff-Wärme-Kraft* **7,** 7, 300–302, July 1955.

Discharge in a pipe is proportional to the square root of the differential head in a throat meter, and therefore the average discharge of the pulsating flow is proportional to the mean value of the square root of the same head. Author determines the error committed by taking the average discharge proportional

to the square root of the *average* head, which is more conveniently calculated, and finds this error contained within 0.1%, hence acceptable even when the discharge varies from the mean value about 10%. D. Citrini, Italy

260. Elliott, D. E., The measurement of high speed velocity and temperature using sound wave photography, *Aero Quart.* **6,** part 3, 181–195, Aug. 1955.

A method of air velocity measurement is described wherein the shadowgraphs of sparks from series spark gaps, one in the air stream and one outside in ambient air, are registered on the same photographic negative. By comparison of two successive exposures at known intervals (e.g., 25 microsec), the average velocities during this interval of sound in normal air and in a transparent tunnel section have been compared at Mach 0.47, with errors of the order of 2%. The method is suggested for transient measurements in pulsation or explosion phenomena. Examples of sound-wave photographs are shown.

Various errors and their corrections are discussed, such as allowance for the initial supersonic velocity of the sound waves from a spark discharge. Author proposes a number of refinements of the optical system and other components used, which might allow shorter time intervals and higher accuracy.

P. Erlandson, USA

261. Itaya, S., and Takenaka, T., Measurement of oil flow by means of 60° sharp-edged triangular weir (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 94–100, 1955.

262. Kettle, D. J., The design of static and pitot static tubes for subsonic speeds, *J. roy. aero. Soc.* **58,** 528, 835–837, Dec. 1954.

263. Macmillan, F. A., Viscous effects on flattened pitot tubes at low speeds, *J. roy. aero. Soc.* **58,** 528, 837–839, Dec. 1954.

264. Murdock, J. W., Faltz, C. J., and Gregory, C., Jr., Effect of a globe valve in approach piping on orifice meter accuracy, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-122, 8 pp.

265. Eckert, E. R. G., and Irvine, T. F., Jr., Simultaneous turbulent and laminar flow in ducts with noncircular cross sections, *J. aero. Sci.* **22,** 1, 65–66, Jan. 1955.

Note in Readers' Forum. Flow visualization techniques and probing of the velocity field have been used to examine the flow of air through a triangular duct having the shape of isosceles triangle with a height-to-base ratio of 5:1. The duct length was 80 hydraulic diameters and the flow entered the duct through a well-rounded entrance.

These studies revealed the unexpected fact that over the whole tube length, laminar and turbulent flow coexist side by side over a considerable Reynolds number range. The flow near the base of the tube is found to be turbulent, whereas near the apex flow remains laminar. From authors' summary

266. Runyan, H. L., Woolston, D. S., and Rainey, A. G., Theoretical and experimental investigation of the effect of tunnel walls on the forces on an oscillating airfoil in two-dimensional subsonic compressible flow, *NACA TN* 3416, 41 pp., June 1955.

Study is given to theoretical and experimental analysis of the quantitative and qualitative effects of tunnel section on subsonic aerodynamic forces on an oscillating airfoil.

Authors discuss the integral equations resulting from reduced frequency and acoustical effects on oscillating coefficients and demonstrate by analytical and experimental means the solution of these equations.

Reviewer believes this report is a valuable consolidation and extension of previous work in this category.

J. B. Duke, USA

267. Lüscher, F., Method for the estimation of the damping coefficients in transonic and supersonic tunnels (in German), *ZAMP* **6,** 3, 243–247, 1955.

Test difficulties obviate the application of the methods normally used for the determination of damping coefficients of wind-tunnel models, namely, decay tests or tests with constrained oscillation, respectively.

To prevent these difficulties the "rotor method" has been developed and successfully tested in a transonic wind tunnel.

With this method the model carries out an oscillation with constant amplitude, which consumes the energy of a rotor wheel. The damping quantity can be determined by measuring the oscillation frequency as a function of time without influence of the oscillation. By running a test without model but with an equivalent mass, damping and frictional components can be separated.

From author's summary

Thermodynamics

(See also Revs. 215, 224, 225, 252, 258, 260, 261, 284, 287, 288, 292 295, 297, 307, 308, 309, 315, 317, 325, 332)

268. Planck, M., Lectures on thermodynamics [Vorlesungen über Thermodynamik], 10th ed. (rev. and enlarged by v. Laue, M.), Berlin, Walter de Gruyter & Co., 1954, xiv + 306 pp. DM 22.

In taking up M. Planck's "Thermodynamics" 58 years after the publication of the first edition and leafing through its pages, one is astonished to find how standard the methods and reasoning developed in this book have become for today's system of thermodynamics. Planck's treatise laid in an almost insurpassable way the foundation of a phenomenological treatment of this branch of physical sciences founded on the two fundamental laws of thermodynamics, to which was added, in the third edition, Wien's third law.

Planck himself could guide and revise nine editions. This tenth German edition published in 1954 was edited by M. v. Laue. Besides some small changes (the symbol "W" for heat function was altered to "H"), a new chapter was added discussing Le Chatelier-Brauns principle, a subject to which Planck himself devoted his last thermodynamics paper.

The new German edition satisfies an urgent demand—the previous ones have been sold out for many years—and will help to keep this classic text, which has been translated into many languages, alive. E. R. G. Eckert, USA

269. Tsien, H. S., Thermodynamic properties of gas at high temperatures and pressures, *Jet Propulsion* **25,** 9, part 1, 471–472, 478, Sept. 1955.

For use in the analysis of gas phenomena at high temperatures and densities, there is proposed the semi-empirical equation of state

$$z = 1 + \frac{1}{0.278\eta - 0.177}$$

where $\eta = (T/\theta_1)^{1/6}(v/v^*)$; $\theta_1 = \epsilon^*/k$ is the characteristic temperature for the low velocity molecular collision potential, ϵ^*; and v^* is the covolume based on the cube of molecular diameter. The numerical constants are empirical. This equation is shown

to correlate adequately with the high-temperature, low-density virial form and with the high density conditions of the Halford-Kistiakowsky-Wilson equation. Energy functions based on the equation of state are developed. N. A. Hall, USA

270. Sänger-Bredt, I., The role of the adiabatic exponent in case of chemically variable gas mixtures (in German), *ZAMP* **6,** 1, 35–66, Jan. 1955.

Author derives for a chemically reacting gaseous mixture the expressions for isentropic exponents defined as the ratios of small fractional changes of selected pairs of state variables when the mixture undergoes slow isentropic change at complete thermo-mechanical and thermochemical equilibrium. Calculated values of these exponents are given for dissociating hydrogen gas for pressure ranging from 0.001 to 100 atm and for temperature from 0 to 5500 K.

The treatment is clumsy. The first third of the paper is devoted to expressing some well-known relations for chemically frozen systems in complicated but straightforward formulas. There are some minor errors and inaccuracies in statement.

It is correct that the thermal equation of state of a reacting mixture becomes identical with that of nonreacting ones, provided there is no change of mole number. But it is certainly astonishing and against one's intuition to read that under the same condition the equations for calorific phenomena, such as for isentropic changes, should also apply in both cases. Closer check of author's algebra reveals that she has erroneously put an extra factor of $\Delta\nu$ (increase of mole number) to all the terms expressing the effects due to enthalpy and entropy of reaction in her Eqs. (41) to (47) inclusive.

In the examples of application, errors also slip in. The speed at the throat of a frictionless Laval nozzle must, in any case, be equal to the sonic speed, but author's Eq. (49a) indicates otherwise. Finally, the practical usefulness of applying such equilibrium treatment to flow phenomena of dissociative medium is dubious. The chemical equilibrium is seldom completely thawed for such processes.

In spite of these drawbacks, the paper is still noteworthy in its minuteness and soundness in principle. The numerical values calculated for hydrogen dissociation and presented in a set of curves are correct. The erroneous factor $\Delta\nu$ is fortunately unity. These curves are certainly a valuable contribution.

L. S. Dzung, Switzerland

271. Holleran, E. M., Interrelation of gaseous viscosity, self-diffusion, and isotropic thermal diffusion, *J. chem. Phys.* **23,** 5, 847–853, May 1955.

According to the correct kinetic theory of gases the thermal diffusion ratio is, like the other transport coefficients, a function of a limited number of "collision integrals." It has proved, so far, impracticable to arrive at a correct expression for the collision integrals, in particular their temperature dependence, or at the correct relation between these integrals and the transport coefficients. In the present paper a number of approximations are discussed; part of these approximations have been put forward in the literature, part of them are suggested by the author. Possible relations between different transport coefficients are examined from the point of view both of a consistent theory and of agreement with experimental results for argon.

Within its limited scope this paper contains useful information.

R. Eisenschitz, England

272. Noeggerath, W., General enthalpy-temperature-entropy diagram for ideal gases and gas mixtures up to 5000 K, *Jet Propulsion* **25,** 9, part 1, 454–462, 470, Sept. 1955.

The enthalpy and entropy of all di- and triatomic gases and their mixtures to 5000 K and in the perfect gas state are represented in a single general diagram. Values for individual gases are obtained by attributing to each gas two parameters. The parameters for N_2, H_2O, and CO_2 are constants; those for other gases, including monatomic and polyatomic gases, are nearly constants over most of the temperature range. The properties of gas mixtures can also be approximately determined from the same plot. J. A. Beattie, USA

273. Charnley, A., Rowlinson, J. S., Sutton, J. R., and Townley, J. R., The isothermal Joule-Thomson coefficient of some binary gas mixtures, *Proc. roy. Soc. Lond.* (*A*) **230,** 1182, 354–358, June 1955.

The limiting value at zero pressure of the isothermal Joule-Thomson coefficient has been measured from 0 to 45 C for the mixtures carbon dioxide + nitrous oxide, carbon dioxide + ethylene, nitrous oxide + ethylene, and nitrous oxide + nitrogen. These measurements are compared with a statistical theory of mixed gases composed of nonspherical molecules. The change of the zero-pressure coefficient with composition in the binary mixtures is shown to agree better with the calculated values for mixtures of nonspherical molecules than those for mixtures of spherical molecules. From authors' summary

274. Michels, A., Schamp, H. W., and De Graaff, W., Compressibility isotherms of oxygen at 0°, 25°, and 50°C and at pressures up to 135 atmospheres, *Physica* **20,** 12, 1209–1214, Dec. 1954.

275. Myers, H. S., Vapor pressure chart for all types of low boiling hydrocarbons, *Indust. Engng. Chem.* **47,** 8, 1659–1660, Aug. 1955.

276. Myers, H. S., and Fenske, M. R., Measurement and correlation of vapor pressure data for high boiling hydrocarbons, *Indust. Engng. Chem.* **47,** 8, 1652–1658, Aug. 1955.

277. Aubert, M., and Sivolobov, N., Specific heats and entropies of hydrocarbons and combustible liquids (in French) *Publ. sci. tech. Min. Air. France.* no. 297, 1955.

278. Garvitch, Z. S., A field instrument for measuring temperatures of natural boiling pools, *J. sci. Instrum.* **32,** 7, 261–263, July 1955.

A prototype instrument is described by which the temperature of natural boiling pools may be compared with the local boiling point of pure water. The difference in temperature is indicated by a meter on which changes of 0.02 C are easily detectable. The power required is provided by a motorcycle battery, and the whole instrument is mounted on a pack frame. A proposal for an improved lighter model of the instrument is included. The equipment may also have use as an alpine height-finder.

From author's summary

279. Muller-Girard, O., The dynamics of filled temperature-measuring systems, *Trans. ASME* **77,** 4, 591–595, May, 1955.

A liquid-filled cylindrical bulb connected to a Bourdon tube is used to measure certain well-defined temperature transients. Author compares his experimental results with the analytical solution for the analogous lumped parameter system containing two capacitances—those of the bulb and of the liquid. Discussion of responses to step, ramp, and sinusoidal inputs is included.

R. E. Gaskell, USA

280. **Glawe, G. E., and Shepard, C. E., Some effects of exposure to exhaust-gas streams on emittance and thermoelectric power of bare-wire platinum rhodium-platinum thermocouples,** *NACA TN* 3253, 30 pp., Aug. 1954.

Exposure to exhaust-gas streams from the combustion of propane, 72-octane gasoline, and MIL-F-5624A grade JP-4 fuel caused negligible changes of the thermoelectric power of unshielded platinum 13% rhodium-platinum thermocouples. The increase in the effective total hemispherical emittance during exposure accounted for the increase of radiation error, the source of apparent error between the test thermocouples and the working standards. Authors give detailed description of the equipment used: Meker burners, a high-temperature tunnel with brick-lined and Inconel combustors, and turbojet and ramjet engines. They show the variation of the effective total hemispherical emittance with the length of time of exposure to the various gas streams required for correction of the radiation error. The technique, apparatus, and results of measuring the total hemispherical emissivity of clean and coated wires are given. Quantitative agreement exists between final effective emittances measured and the final effective emittances computed from the measured radiation error. They suggest that, in applications where long time reproducibility of the thermocouple is desired, pre-exposure to operating conditions can establish a condition of stable effective emittance. C. E. Moeller, USA

281. **Eijkman, E. G. J., Errors in measuring dynamic temperatures** (in Dutch), *Ingenieur* **67,** 5, 15–20, Feb. 1955.

Time lags of different thermometers are investigated. The behavior of thermometers is studied in media which have linearly varying temperature, sinusoidal changes of temperature, or undergo a sudden change of temperature. The results should help to judge the dynamic errors of thermometers in measuring varying temperatures. I. Flügge-Lotz, USA

282. **Viets, D., Measurements of temperature in fast flowing gases** (in Dutch), *Ingenieur* **67,** 7, 31–35, Feb. 1955.

The heat generated by friction and compression along the bulb of a thermometer becomes considerable when the gas velocity is higher than 50 m/sec. By means of thermodynamics the static and total temperatures are defined and computed for some examples. The temperature indicated by a thermometer always lies in between the static and total temperature. The difference between the actual and static temperature divided by the difference between total and static temperature is called the "recovery factor." It appears that, in general, the recovery factor is dependent on the velocity and the shape of the thermometer. By means of special constructions a constant recovery factor has been obtained. Thus it has become possible to measure the temperature up to velocities of 300 m/sec with an error less than 0.5 C. J. A. Businger, Holland

283. **Livengood, J. C., Rona, T. P., and Baruch, J. J., Ultrasonic temperature measurement in internal combustion engine chamber,** *J. acoust. Soc. Amer.* **26,** 5, 824–830, Sept. 1954.

A method and apparatus for measuring the velocity of propagation of sound in the gases within the combustion chamber of an operating internal-combustion engine are described. Two barium-titanate crystals are used to generate and receive transient acoustical signals of approximately 2 mcps. A calibrated commercial oscilloscope is the time base of the system.

From the value of the velocity of sound it is possible to compute the temperature of the portion of the engine gas which lies in the measuring path, provided it is permissible to assume that the gas mixture behaves like a perfect gas, that it is of known composition, and that thermal relaxation effects are negligible. The maximum error is estimated at 4.7% and experiments indicate a dispersion of results less than 1%. From authors' summary

Heat and Mass Transfer

(See also Revs. 77, 79, 150, 159, 162, 200, 215, 260, 268, 270, 271, 278, 279, 280, 281, 282, 283, 311)

284. **Schneider, P. J., Conduction heat transfer,** Cambridge, Addison-Wesley Publ. Co., Inc., 1955, xi + 395 pp. $12.50.

This book is designed for use as a text in a first semester graduate course in heat conduction. Although, like most books on this subject, it is concerned primarily with the analytical solution of boundary-value problems, only the usual undergraduate background in the calculus and ordinary differential equations is required as a prerequisite to its use. The text encompasses a variety of engineering systems, and the analysis of these systems is presented with a conspicuous lack of the mathematical rigor ordinarily awarded solutions in potential field theory. In the process of solving heat-conduction problems the student is introduced to Fourier series, the ordinary differential equations of Bessel and Legendre, and to two useful methods of attacking partial differential equations, namely, the Laplace transform method and the separation of variables method.

Although two thirds of the book deals with the analytical method of solution, author also treats the numerical, graphical, and experimental methods and attempts to introduce the student to the power and limitations of each method. It is emphasized that the method which may be best for one problem might be the worst for another problem.

Those pedagogues who believe that more of the mathematics for engineers should be taught in engineering courses by engineering teachers will approve of this introductory text in heat conduction. D. C. Hamilton, USA

285. **Barzelay, M. E., Tong, K. N., and Holloway, G. F., Effect of pressure on thermal conductance of contact joints,** *NACA TN* 3295, 52 pp., May 1955.

As an extension of previous experimental work [see AMR 8, Rev. 2117], further tests were conducted to determine the factors influencing the thermal conductance across the interface formed between stationary plane surfaces of 75S-T6 aluminum alloy and AISI type 416 stainless-steel blocks. The types of joints investigated included bare metal-to-metal contact, contact surfaces separated by a good conductor (brass shim stock), and contact surfaces separated by a thin sheet of insulation (asbestos). From authors' summary

286. **Vodička, V., Circular cylinder in a periodic temperature field,** *Appl. sci. Res. (A)* **5,** 4, 268–272, 1955.

A solution is obtained for the transient temperature in an isotropic finite circular cylinder with surfaces exposed to an ambient medium whose temperature varies periodically. The uniform unit surface conductance of the end surfaces, and the amplitude and frequency of the periodic ambient temperature for the cylindrical surface may have different values than these for the end surfaces. This case is a generalization of the author's previous solution in which unit surface conductances and periodic ambient temperatures are the same for all surfaces.

No practical examples are cited, nor is the reviewer aware of any physical system which might accurately impose such boundary conditions. P. J. Schneider, USA

287. Bosanquet, C. H., and Aris, R., On the application of Ångström's method of measuring thermal conductivity, *Brit. J. appl. Phys.* **5,** 7, 252–255, July 1954.

Ångström's method of measuring thermal diffusivity of thin bars requires the determination of amplitude ratio and phase shift of the first Fourier component of temperature waves at two measuring stations along the length of the bar. By selecting heat input of a rectangular wave form, authors demonstrated the possibility of evaluating such amplitude ratio and phase shift from the recorded temperature waves without having recourse to Fourier analysis. The procedure involves a series of successive corrections. To facilitate computation, charts are given for finding such corrections.

While the reviewer concurs with the authors that, in practice, it is not easy to perform complete Fourier analysis of the temperature wave without sacrificing accuracy, to generate a sinusoidal temperature wave at a location not too close to the heating end of the Ångström bar is not difficult. King's arrangement has recently been successfully applied by the reviewer [ASME pap. no. 55—SA-36]. The higher harmonics were damped out very rapidly as one moved away from the end.

Reviewer wishes to point out the fact that Ångström's method and the modification suggested by the authors determine the thermal diffusivity but not conductivity of the bar material.

Following Eq. (15), the expression $\kappa^2 l = \ln (A_1/A_2)$ should read $\kappa l = \ln (A_1/A_2)$. B. T. Chao, USA

288. Rosenthal, D., and Friedmann, N. E., Thermal diffusivity of metals at high temperatures, *J. appl. Phys.* **25,** 8, 1059–1060, Aug. 1954.

289. Mattarolo, L., On the first results of the measurements of temperature in a large concrete dam (in Italian), *Termotecnica* **8,** 7, 397–405, July 1954.

Analytical analysis of experimental temperature data recorded on a concrete dam during a two-year period. The purpose of the analysis is to compute the thermal diffusivity of the concrete from the measured temperature distribution during the two-year period. Temperatures have been measured at two points along the thickness of the dam. Author assumes a one-dimensional transient problem and therefore neglects the temperature variations of the water with depth. Results show only qualitative conclusions, which is not a surprise to the reviewer.

S. Eskinazi, USA

290. Baehr, H. D., A contribution toward the graphical estimation of transient temperatures by the method of finite differences (in German), *Forsch. Geb. Ing.-Wes.* **20,** 1, 16–19, 1954.

The graphical method of approximation to the temperature distribution in nonsteady heat flow through solids due to Schmidt, E. [title source, **13,** 177–85, 1942] are simplified for the case of the sphere and the infinite cylinder. It is extended also to the case of the radiation type of boundary condition, and to cases of one-dimensional flow through layers of differing material characteristics. The graphical construction of successive temperature contours is readily carried out. Examples given include the cooling of a long steel shaft in an oil bath and the heating up of a furnace wall consisting of refractory and insulating layers.

M. A. Mayers, USA

291. Dietze, H. D., Thermal stress in a sphere due to a periodic fluctuation of the surface temperature (in German), *Tech. Mitt. Krupp* **13,** 3, 62–65, July 1955.

Author assumes that the velocity of the thermal waves is small enough to be neglected with regard to the velocity of the elastic waves. In a polar diagram the stresses at the centers and at the surface of the sphere are plotted as a function of the radius R, the frequency of the surface temperature, and the material constants. It is shown that, according to the criterion for plastic deformation of von Mises, the critical zone is at the surface of the sphere. J. W. Cohen, Holland

292. Lemlich, R., and Sharn, C., Natural convection to cold cylinders, *Indust. Engng. Chem.* **47,** 8, 1547–1550, Aug. 1955.

Within the limits of the dimensionless groups and experimental precision of this investigation, and providing Δt is not too large, the results for natural convection to cold horizontal cylinders agree with those for natural convection from warm horizontal cylinders. The inversion in temperature and velocity profiles is without effect, and the same generalized correlation, such as that of McAdams, applies to either. From authors' summary

293. Deissler, R. G., and Taylor, M. F., Analysis of fully developed turbulent heat transfer and flow in an annulus with various eccentricities, *NACA TN* 3451, 42 pp., May 1955.

A previous analysis [AMR 7, Rev. 1274] for turbulent heat transfer and flow in tubes is generalized and applied to an annulus with various eccentricities. Expressions for eddy diffusivity which were verified for flow and heat transfer in tubes are assumed to apply in general along lines normal to a wall. Velocity distributions, wall shear-stress distributions, and friction factors, as well as wall heat-transfer distributions, wall temperature distributions, and average heat-transfer coefficients, are calculated for an annulus having a radius ratio of 3.5 at various eccentricities. From authors' summary by R. H. Norris, USA

294. Brevoort, M. J., and Rashis, B., Turbulent-heat-transfer measurements at a Mach number of 1.62, *NACA TN* 3461, 15 pp., June 1955.

Turbulent heat-transfer measurements were obtained through the use of an axially symmetric annular nozzle which consists of an inner shaped center body and an outer cylindrical sleeve. Measurements taken along the outer sleeve gave essentially flat-plate results that are free from wall interference and corner effects for a Mach number of 1.62 and for a Reynolds number range of 7.22×10^6 to 1.20×10^8. The heat-transfer coefficients are in good agreement with theoretical results for a Mach number of 1.60 and for a ratio of inner-surface to free-stream temperature of 1.60. The temperature-recovery factors are on the average 1.5% lower than the factors obtained for a Mach number of 2.4.

From authors' summary

295. Fleishman, B. A., and Frenkiel, F. N., Diffusion of matter emitted from a line source in a non-isotropic turbulent flow, *J. Meteor.* **12,** 2, 141–145, Apr. 1955.

Mean concentration distributions in a homogeneous turbulent field with mean flow normal to the line source are determined in terms of the statistical properties of the turbulence. Asymptotic formulas are given for distances which are both large and small compared with the Lagrangian scales. Detailed results are shown for the isotropic case with two assumed correlation coefficients.

Paper discusses upwind dispersion resulting from high intensity of turbulence in the wind direction, and shows iso-concentration curves for such a case.

Reviewer believes that the paper would have benefited by comparison with the measurements of Uberoi and Corrsin [*NACA Rep.* 1142, see AMR **8,** Rev. 818; **6,** Rev. 226] and Townsend [*Proc. roy. Soc.* (*A*) **224,** p. 487]. W. Daskin, USA

296. **Bory, C., Theoretical study of heat convection with a movable wall: generalization of the method** (in French), Fluid Mech. Meeting (Marseille, 1952); *Publ. sci. tech. Min. Air. France* no. 269, 277–281, 1955.

Considerations are essentially the same as in author's previous paper [AMR **5**, Rev. 2099]. H. A. Vreedenberg, Holland

297. **Shoemaker, R. W., Radiant heating, 2nd ed.,** New York, McGraw-Hill Book Co., Inc., 1954, x + 346 pp. $7.

This second edition of a book first published in 1948 is considerably revised in detail and illustrations, and two new chapters, on electrical heating and on miscellaneous radiant-heating applications, have been added.

It is not a textbook in the usual sense. It is almost conversational in presentation; it is copiously illustrated, largely with photographs showing the external appearance of equipment and buildings, and, except for one chapter, relatively free of mathematics, formulas, and graphical data.

Written on a semitechnical level, it is apparently addressed mainly to builders, mechanics, architects, and the interested public. Because it supplies considerable practical information it would make good background reading for engineers who have occasional contact with this field. F. C. Hooper, Canada

298. **Sabersky, R. H., and Gates, C. W., Jr., On the start of nucleation in boiling heat transfer,** *Jet Propulsion* **25**, 2, 67–70, Feb. 1955.

Experiment is intended to furnish understanding of one possible cause of burnout of reactor or furnace tubes cooled by boiling water. Particularly in nuclear reactors, extremely high purity of water might cause delay in initiation of boiling due to lack of suitable nuclei assumed to be impurities of gases or solids.

Author studied mechanism of bubble formation on 0.010-in. diam nickel and platinum wire immersed in water. By subjecting entire vessel of water to 15,000 psi pressure for over 15 min, nucleation on cleaned wires starts only at temperature considerably higher than boiling point. Once boiling starts, conditions revert to normal. For conditions studied, effect on burnout heat flux is small.

Results are clearly presented. Reviewer feels that further experiments would be needed to prove conclusions apply to conditions of high pressure boiling or low values of "subcooling," defined as difference between normal boiling temperature and actual water temperature. Paper covers heat flux from 2 to 10 Btu/(sq in-sec) for burnout, with subcooling from 20 F to 140 F. Maximum flux for free convection before beginning nucleation is less than 1 Btu/(sq in-sec), which is a rate beyond point at which nucleate boiling starts in untreated water.

D. Aronson, USA

299. **Sterman, L. S., Heat exchange theory applied to liquids boiling in pipes** (in Russian), *Zh. tekh. Fiz.* **24**, 2, 250–257, Feb. 1954.

Author writes the momentum balance and the energy balance for one-dimensional flow of a gas-liquid mixture inside a pipe. A complete dimensional analysis based on these equations and the boundary conditions shows that the Nusselt number is a function of ten additional dimensionless groups. The significance of these groups is discussed and the author's list of dimensionless groups is compared with those of previous authors.

C. V. Sternling, USA

300. **Gilbert, M. J., and van Bavel, C. H. M., A simple field installation for measuring maximum evapotranspiration,** *Trans. Amer. geophys. Un.* **35**, 6, 937–942, Dec. 1954.

Soil-filled gasoline drums (55 gal) have been used to measure maximum evapotranspiration at Waynesville, North Carolina. Installation involves no mechanical devices, and maintenance is at a minimum. Water is added manually to prevent water supply to the plants from becoming a limiting factor. Tensiometers are used to indicate when water must be added. Tanks are placed in the center of areas of the same vegetation. Data for one year under grass cover are presented and compared with values calculated from Thornthwaite's and Penman's formulas. The latter appears, upon statistical analysis, to fit the data better than the former. From authors' summary

301. **Okazaki, T., and Kubota, E., On the effect of the air on film condensation (3rd Report)** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 104, 291–296, 1955.

There are many experiments about the title subject but, lacking physical understanding of the diffusion phenomena, they can be applied only to the same conditions as their experiments.

In the present paper, authors calculate theoretically the effect of the air contained in the steam on the coefficients of heat transfer, taking into consideration the velocity field due to the suction effect and the surface velocity of the water film and the natural convection caused by the density difference.

From authors' summary

302. **Mason, J. L., Heat transfer in a crossflow,** *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech. Engrs., June 1955, 801–803.

Crossflow temperature difference for a single pass exchanger, both fluids unmixed, is derived by use of Laplace transform, giving a more rapidly converging solution than the original Nusselt solution. Mathematical paper, no curves included.

A. C. Mueller, USA

303. **Kays, W. M., Pin-fin heat-exchanger surfaces,** *Trans. ASME* **77**, 4, 471–483, May 1955.

See AMR **7**, Rev. 2613.

304. **Kühl, H., Influence of design and operational data on the performance of heat exchangers for gas turbines with similar heat transfer elements** (in German), *Motortech. Z.* **16**, 4, 98–106, Apr. 1955.

Paper deals with heat exchangers for gas turbines composed of plain tubes. Assuming similarity in the geometry and simple power functions describing heat transfer and pressure drop, relations are developed which describe the heat-transferring area per unit mass of gas flow as a function of thermal effectiveness, pressure and temperature level, pressure drop, and tube diameter. The relationships are utilized to determine the optimum pressure drop which, for a prescribed heat-exchanger area, results in the maximum value of the thermal efficiency of the gas-turbine unit. It is pointed out that the heat-exchanging area per unit power required to drive the coolants through the heat exchanger increases nearly proportionally to the Prandtl number of the coolants. It is proposed to utilize this factor in a closed-cycle gas turbine by using a mixture of two gases with very different molecular weight as working fluid. According to kinetic theory, such a mixture has a Prandtl number which is appreciably smaller than the Prandtl number for pure gases.

E. R. G. Eckert, USA

305. **Palladino, N. J., The thermal design of nuclear power reactors,** *Trans. ASME* **77**, 5, 667–673, July 1955.

See AMR **8**, Rev. 1177.

306. Hammond, W. E., Giblon, R. P., and Hoch, C. E., Rotary regenerative heaters for shipboard installations, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Paper 55—S-32, 22 pp.

307. Thurlow, G. G., Corrosion studies on a model rotary air-preheater, *Instn. mech. Engrs. Proc.* **168,** 20, 571–578, 1954. See AMR **7,** Rev. 3752.

308. Simonson, W. F., Boiler design and availability, *Boiler Availability Comm. Lond. Bull.* MC/255, 23 pp., Oct. 1954.

309. Orlowski, P., Actual state of boiler construction (in Polish), *Przegl. tech.* **75,** 7, 246–247, July 1954.

Combustion

(See also Revs. 184, 270, 275, 276, 277, 280, 308, 332)

310. Summerfield, M., Reiter, S. H., Kebely, V., and Mascolo, R. W., The structure and propagation mechanism of turbulent flames in high speed flow, *Jet Propulsion* **25,** 8, 377–384, Aug. 1955.

The space heat-release characteristics of flames in high-speed flow are needed for the design of ramjet combustors. Such information may be obtained from a knowledge of the internal structure of turbulent flames. The accepted model of a turbulent flame has been a wrinkled laminar flame zone moving about within the turbulent flame brush. Authors present some experimental evidence for an alternate model—a thickened reaction zone with smooth spatial variations of the time-average values of composition and temperature. Two-dimensional turbulent burner flames are used for (1) filtered photographs, (2) spectroscopic traverses, (3) ionization probe measurements, and (4) temperature distributions across the flame zone. The most convincing evidence is the observed difference in radiation characteristics of laminar and turbulent flames.

The reviewer believes that the proposal of another turbulent flame model is timely, but that the experimental evidence is as yet insufficient to establish the new model.

D. M. Simon, USA

311. Baron, T., Reactions in turbulent free jets—the turbulent flame, *Chem. Engng. Prog.* **50,** 2, 73–76, Feb. 1954.

In a turbulent diffusion flame the flow transport or convection depends on the distribution of mean and fluctuating velocities. This physical situation is expressible by a set of nonlinear partial differential equations, the equations of motion, of continuity of each chemical species, and of energy. The author uses the Fourier-Poisson equation for heat transfer (neglecting radiation) and mass transfer and assumes that a quasi-steady state exists for which the time derivatives of the mean quantities vanish. The Baron and Alexander modification of Reichardt's hypothesis is employed to introduce the effect of turbulence on the various flux distributions. This approach is claimed to be superior to the phenomenological basis used by Prandtl and Taylor, for free jet systems. The resulting equation expressing the principles of conservation of energy, of mass, and of momentum are given in cylindrical coordinates. This theory is applied to free jets without and with appreciable buoyant forces and to turbulent diffusion flames without and with appreciable buoyant forces. Finally, the time-mean rate of reactions with high activation energies may differ by an order of magnitude from the rate corresponding to the time-mean conditions.

B. P. Mullins, England

312. Cheng, S.-I., On "Unstable burning of solid propellants," *Jet Propulsion* **25,** 2, 79–80, Feb. 1955.

313. Miao, Y. M., Price, T. W., and Potter, J. H., Transient gas-flame temperatures in a spherical bomb, *Trans. ASME* **77,** 1, 89–96, Jan. 1955.

The transient-flame temperature in a gaseous mixture, burning in a constant-volume spherical vessel from a point of central ignition, has long been of interest. Flamm and Mache developed a theoretical analysis relating the adiabatic temperature distribution to measured values of the bomb pressure. In this investigation, a modified sodium D-line method was used to determine temperatures at several radii on a spherical vessel. Pressure measurements also were taken. Comparison is offered between the measured transient-flame temperatures and those computed from the Flamm and Mache equations.

From authors' summary

314. Burgoyne, J. H., and Weinberg, F. J., "Excess energy" hypothesis of flame behaviour—Discussion of basic assumptions, *Fuel* **34,** 3, 351–355, July 1955.

Authors reply to criticisms of "excess energy" hypothesis [see AMR **8,** Rev. 2908]. Criticism is that consideration of diffusional energy transfer invalidates the hypothesis and hence its implications. Contention is that the physical basis of hypothesis is sound for specific applications and that experiment will decide if theory is to be rejected.

M. Gilbert, USA

315. van Wonterghem, J., and van Tiggelen, A., Activation energy in flame propagation (in French), *Bull. Soc. chim. Belges* no. 64, 99–121, 1955.

316. Kinbara, T., and Nakamura, J., On liquid-fuel flames in longitudinal electric field, *Sci. Pap. College gen. Education. Univ. Tokyo* **4,** 1, 21–34, 2 plates, July 1954.

This work was undertaken to decide whether the deformation of flame by an electric field is due to a direct influence on the combustion process or to a mechanical effect on the ions in the flame. The experiments were carried out with diffusion flames on lamp-wick burners, employing a water-cooled tip with a cotton wick. The fuels included gasoline, alcohol, benzene, and amyl-acetate which was employed in most of the experiments. The distribution of the electric potential and relative conductivity in the flame were determined by electric probes, and this, coupled with thermocouple measurements of the temperature distribution, led to the following conclusion: the electrons and positive ions are created primarily in the "green premixed gas-combustion zone" of the diffusion flame; as they ascend with the burned gas, the electrons diffuse out of the flame more rapidly than the positive ions, leaving the flame positively charged. In a second set of experiments where an electric field was applied by placing either positive or negative screens above the flame, the flame was deformed and sometimes extinguished.

Authors observed the deformation of the flame and potential distribution through the flame in addition to observations of the height and brightness temperature. It was concluded that the distortion of the flame is due to a Chattock wind—that is, mechanical forces of the ions on the combustion gases—and that there is no evidence that ions play any part in the chemistry of combustion. The extraordinary sensitivity of these lamp-wick flames to an electric field was attributed to the diminution of vaporization of the fuel as a natural result of flame deformation.

H. F. Calcote, USA

317. **Das, T. K., Gas turbine combustion chamber for liquid fuels,** *J. Instn. Engrs., India* **35,** 1, 101–105, Sept. 1954.

Development of the combustion chamber of a gas turbine, like its other components, is handicapped due to the lack of sufficient technical data. Design data are mostly empirical, and therefore the final design depends to a very large extent on the experience gained by actual testing of model chambers. The combustion chamber for this project has been developed with the experience gained from testing of three model combustion chambers designed for this purpose. This paper reports the design data and test results of the final combustion chamber which has been developed. From author's summary

318. **Friedman, R., and Carlson, E. R., A polar-coordinate survey method for determining jet-engine combustion-chamber performance,** *NACA TN* 3566, 29 pp., Sept. 1955.

The use of an automatic polar-coordinate traversing system for determining jet-engine combustor performance is described. A combined temperature and pressure probe is swept circumferentially through a quarter-annular exhaust duct at selected radial positions. Data are recorded as a function of probe position.

This method furnishes complete temperature, pressure, and flow profiles with a single probe. It provides a means of calculating mass-weighted or area-average mean temperatures and pressures for evaluating combustion efficiency and pressure loss. An example is given to illustrate these procedures.

From authors' summary

319. **Olson, W. J., Childs, J. H., and Johash, E. R., The combustion-efficiency problem of the turbojet at high altitude,** *Trans. ASME* **77,** 5, 605–615, July 1955.

See AMR 8, Rev. 1197.

Acoustics

(See also Revs. 154, 283)

320. **Diaz, J. B., and Landshoff, R., Solution for all values of the time, of initial value problems for the wave equation and for a system of equations in acoustics,** *J. rational Mech. Anal.* **4,** 3, 503–515, May 1955.

Existence and uniqueness theorems for several Cauchy problems are given. J. W. Miles, USA

321. **Keller, J. B., Geometrical acoustics. I. The theory of weak shock waves,** *J. appl. Phys.* **25,** 8, 938–947, Aug. 1954.

This paper provides the mathematical foundation of geometrical acoustics, i.e., the application of methods of geometrical optics to certain phenomena associated with weak shock (acoustic) waves. Author derives discontinuity conditions in arbitrary continuous media and shows that shocks, contact discontinuities, and phase-change fronts are the only possible types of discontinuity. The acoustic equations and discontinuity conditions are obtained and the application of methods of geometrical optics to the description of the motion of the shock front is demonstrated. One of the main results of the treatment is the expression obtained for variation of shock strength along rays. Author shows applications of the method to reflection and transmission at a contact discontinuity and to the shock tube. F. J. Berry, England

322. **Richardson, E. G., The relations between acoustics and hydrodynamics,** *J. acoust. Soc. Amer.* **26,** 5, 615–617, Sept. 1954.

323. **Bleich, H. H., Sound radiation from an elastic cylindrical shell submerged in an infinite medium,** *Proc. second U.S. nat. Congr. appl. Mech.*, June 1954; Amer. Soc. mech Engrs., 1955, 213–223.

Continuing earlier work [H. H. Bleich and M. L. Baron, *J. appl. Mech.* Pap. 53—A-37, 1954], a Fourier integral representation is obtained for the pressure field in the neighborhood of the infinitely long shell when acted on by a space and time periodic, radially directed, external force which is nonperiodic in the axial direction. The integral is evaluated in closed form for points at large radial distances from the axis, the approximation being valid (except in the case of very low frequencies) at distances greater than 50 times the radius of the shell. The results, derived for an unstiffened shell, apply approximately to shells with closely spaced ring stiffeners. Typical pressure curves are plotted for the case of a lightly stiffened, thin steel shell submerged in water, and the case of resonance is studied. R. Heller, USA

324. **Mercier, J., Radiation pressure in fluid** (in French), *Acustica* **4,** 4, 441–446, 1954.

Radiation pressure will appear if sound medium is absorbent or if reflection takes place. Former theories are based on "actual" coordinates but they do not satisfy entirely the acoustic situation. By means of an energetic consideration, author represents radiation pressure as the product of alternating pressure times particle velocity divided by sound velocity. Calculation is illustrated by two simple examples. Distinction between radiation pressure and energy density is followed without difficulty.

P.-P. Heusinger, Germany

325. **Parthasarathy, S., Absorption and dispersion of ultrasonic waves in liquids,** *J. acoust. Soc. Amer.* **26,** 5, 611–614, Sept. 1954.

326. **Holtsmark, J., Johnsen, I., Sikkeland, T., and Skavlem, S., Boundary layer flow near a cylindrical obstacle in an oscillating incompressible fluid,** *J. acoust. Soc. Amer.* **26,** 1, p. 102, Jan. 1954.

Around any obstacle in oscillating fluid (e.g., a microphone in a sound field), interesting flow patterns are set up in connection with pressure and flow disturbances. Authors describe results of observations in a Kundt tube, which are in good agreement qualitatively and quantitatively with calculations based on an iterative solution of the Navier-Stokes equations.

Both experiments and theory reveal a system of stationary vortexes—one in the boundary layer of each quadrant of the cylinder, and corresponding vortexes in the outer flow. The amplitude of the oscillations as a function of the distance from the cylinder can be predicted. H. Merbt, Sweden

327. **Callaghan, E. E., Sanders, N. D., and North, W. J. Recent NACA investigations of noise-reduction devices for full-scale engines,** *Aero. Engng. Rev.* **14,** 6, 66–71, June 1955.

328. **Pietrasanta, A. C., Fundamentals of noise control,** *Noise Control* **1,** 1, 10–18, Jan. 1955.

329. **Kramer, H. P., Note on the emission of noise by supersonic jets,** *J. acoust. Soc. Amer.* **27,** 4, 789–790, July 1955.

330. **North, W. J., Summary evaluation of toothed-nozzle attachments as a jet-noise-suppression device,** *NACA TN* 3516, 19 pp., July 1955.

Toothed attachments to a full-scale turbojet nozzle were investigated for possible jet-noise reduction and thrust penalty.

The attachments caused slight reductions in total sound power that are insignificant when evaluated in terms of engine thrust losses and aircraft payload penalty. At the reduced thrust levels obtained with the toothed nozzles, corresponding sound power reductions could be realized by throttling the standard turbojet engine.

Sound pressure levels were reduced behind the engine but were increased elsewhere. A typical resident in the airport neighborhood would hear increased loudness in the middle frequencies; however, the resulting over-all auditory effect is considered to be negligible. From author's summary

331. Tyzzer, F. G., and Leedy, H. A., Advances since 1929 in methods of testing acoustical performance of acoustical materials, *J. acoust. Soc. Amer.* **26,** 5, 651–656, Sept. 1954.

Ballistics, Detonics (Explosions)

(See also Rev. 118)

332. Gatland, K. W., Development of the guided missile, 2nd ed., New York, Philosophical Library; London, Iliffe & Sons, Ltd., 1954, 292 pp. $4.75.

Book provides a clear and comprehensive review of released data on missiles, second edition being enlarged and three new chapters added dealing with bipropellant and solid-propellant rockets, tabulated data on performance and corrosion, guided bombs using television eye systems, radio locks to overcome interference; a comprehensive review of telemetering systems is also added describing time multiplex and PPM systems. Remaining material has been brought up to date by providing data on new missiles; valuable tables for (140) significant missiles are given (90 in the first edition). Comparative effectiveness of guided missiles and antiaircraft shells, methods of guidance, control and homing devices, problems of bombing from high altitude, star tracking for guidance of long-range missiles, (earth) satellite, high-altitude research rocket, features of design and installation, methods of propulsion, and connected problems are discussed.

Author's views on evolution and future development of missiles are presented, his outlook being rather pessimistic with respect to the possibility of preventing an attack on Great Britain with supersonic missiles. P. Bielkowicz, USA

333. Adamson, T. C., Jr., and Morrison, R. B., On the classification of normal detonation waves, *Jet Propulsion* **25,** 8, pp. 400, 403, Aug. 1955.

Soil Mechanics, Seepage

(See also Revs. 121, 122, 123, 124, 180)

334. Lehmann, P., and Neuber, H., Calculation of earth stresses in computing foundations according to the hypothesis of von Fröhlich (in German), *Bautechnik,* **32,** 2, 44–48, Feb. 1955.

Based on Frölich's hypothesis for stress distribution in soil, authors determine vertical and horizontal stress components due to a line load of finite length, for points located in a vertical plane through one end of the line load and normal to it. The solution of this problem permits then the calculation of stresses due to loads which can be built up from line loads of finite length. For practical applications, the results can be represented in graphs similar to those of Steinbrenner, but of wider application.

E. Rathgeb, Argentina

335. Opsal, F. W., Analysis of two- and three-dimensional ground-water flow by electrical analogy, *Trend. Engng. Univ. Wash.* **7,** 2, 15–20, 32, Apr. 1955.

The general principles of the analysis of two-dimensional and three-dimensional ground-water flow by electrical analogy are outlined and the practical application of this method, made by tests with a new conductive material, is described. The material consists of gelatin, glycerin, water, and salt.

Tests were made successfully with this material to determine the potential distributions around an artesian well, varying the penetration of the well, and also to determine the free surface around a gravity well.

From author's summary by J. A. Cheney, USA

336. Anonymous, Field moisture content investigation, October 1945—November 1952 phase, *Wwys. Exp. Sta. tech. Memo.* 3–401, Rep. no. 2, 71 pp. + xxvi tables + 161 plates + xxxi appendix, Apr. 1955.

This report is the second of a series on the study of moisture conditions under flexible air field pavements. It describes that phase of the moisture-content investigation from October 1945 to November 1952 in which the direct sampling method was used. From summary

337. Ubell, K., Comparison of methods for testing permeability of water-bearing formations (in Hungarian, with English summary), *Viz. Közl.* **1954-2,** 189–200, (31)–(32), 1954.

338. Eastwood, W., Model investigations concerned with driving piles by vibration, *Civ. Engng. Lond.* **50,** 584, 189–191, Feb. 1955.

Paper describes experiments on a model scale to find the factors which affect the natural frequency of vertical vibration of piles. These experiments may give some guidance as to the range of frequencies which will be most likely to give resonance in full-scale attempts at driving piles by vibration.

The following is a summary of the principal findings:

(1) The natural frequency of vibration appears to be approximately constant for a given pile, whatever the depth of penetration.

(2) Increasing the total mass of a given pile reduced its natural frequency. But the reduction was not quite as great as would be expected if the frequency were inversely proportional to the square root of the weight of the pile.

(3) Increasing the cross-sectional area of the pile decreases the natural frequency.

(4) The effect of inundating the sand was to slightly decrease the natural frequency compared with that for damp sand.

From author's conclusions by R. K. Bernhard, USA

339. Leõnov, M. Ya., and Panasiuk, V. V., Stability of drive pipes (in Russian), *Izv. Akad. Nauk SSSR Otd. Tekh. Nauk* no. 5, 51–56, May 1954.

340. Tattersall, F., Wakeling, T. R. M., and Ward, W. H., Investigations into the design of pressure tunnels in London clay, *Proc. Instn. civ. Engrs.* **4,** 4, 400–471, July 1955.

Paper describes an experimental investigation into the behavior of a hydraulic pressure tunnel which was designed and constructed by the Metropolitan Water Board at Ashford Common, Middlesex. The tunnel is 90 ft deep in the London Clay and is lined only with a precast concrete lining 8-ft-4-in. ID which is incapable of carrying any hoop tension. The pressure of the water is therefore transmitted directly to the clay. The object of the

investigation was to determine whether an inner steel lining was necessary, and generally to increase existing knowledge of the earth pressures and internal forces on such tunnel linings.

In collaboration with the Building Research Station, special instruments were designed and constructed to measure directly radial earth pressures, hoop thrust, and diameter changes in the lining, both with the tunnel empty and under pressure. Most of the instruments were remote reading at the surface. The tunnel has been subjected to a head of 160 ft of water. The mechanics of expanding and prestressing the lining have been investigated and suggestions are made for improving this type of tunnel lining. Paper concludes with a discussion of the use and economics of tunnels of this type for the conveyance of water.

From authors' summary

Micromeritics

341. **Kosack, von W., On the influence of temperature on the raw weight and viscosity of sands** (in German), *Zement-Kalk-Gips* **8**, 7, 243–244, July 1955.

Paper reports on the changes of the raw weights of sands in relation to moisture content and varying temperatures. Variations of the raw weights are not very great. They show certain regularities and obey certain laws. Paper also reports on experiments by help of which the variation of the viscosity has been observed in relation to the variation of temperature.

From author's summary

342. **Smith, J. L., Jr., and Goglia, M. J., The mechanism of separation in the louver-type dust separator,** ASME Ann. Meet. N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-134, 22 pp.

A preliminary study of the particle paths in a two-dimensional louver separator was conducted to determine which design features are conducive to good performance.

From authors' summary

Geophysics, Meteorology, Oceanography

(See also Revs. 71, 174, 175, 176, 177, 178, 247)

343. **Chandrasekhar, S., The character of the equilibrium of an incompressible heavy viscous fluid of variable density,** *Proc. Camb. phil. Soc.* **51,** part 1, 162–178, Jan. 1955.

An analytical study is made of a static fluid, to determine the initial manner of development of an infinitesimal disturbance. The problem is reduced to one in characteristic values in a fourth-order differential equation. A variational principle characterizing the solution is enunciated. The results of the calculations are illustrated graphically. Gravity waves are also treated.

R. C. Binder, USA

344. **Proudman, J., The propagation of tide and surge in an estuary,** *Proc. roy. Soc. Lond.* (*A*) **231,** 1184, 8–24, July 1955.

This theoretical study of nonlinear interaction of periodic tide wave and isolated surge in a channel of variable section, including friction, should prove useful in understanding phenomenon of flood waves in estuaries due to abnormal storm produced, or Tsunami water-level changes in open sea.

H. Stommel, USA

345. **Cramer, H. E., and Record, F. A., Power spectra of the eddy-velocity components,** *J. Meteor.* **12,** 2, 146–151, Apr. 1955.

Power spectra of the eddy-velocity components have been determined at four levels within the layer from 2 to 12 meters under varying conditions of mean wind speed, trajectory, and thermal stability. A filtering technique suggested by J. W. Tukey has been used to obtain rough estimates of contributions to the total variance for seven consecutive frequency intervals within the range from about 0.5 to 0.005 cps. At the higher frequencies studied, variances for all three components are approximately equal and equipartition of turbulent energy is thus indicated. Spectra for the u- and v-components appear to be invariant with frequency at the lowest level, and then to increase slowly with decreasing frequency at the higher levels. The w-spectra at all levels fall off sharply with decreasing frequency, contributions to the vertically-directed energy becoming almost negligible at the lowest frequencies investigated.

From authors' summary by E. Leimanis, Canada

Lubrication; Bearings; Wear

(See also Revs. 39, 147, 148, 149)

346. **Vogelpohl, G., The Stribeck curve as a characterization of the general friction behavior of lubricated surfaces** (in German), *ZVDI* **96,** 9, 261–268, Mar. 1954.

Author's aim is to show that the working conditions of journal bearings, deduced from the experiences of Stribeck made in 1902, are in accordance with the laws of hydrodynamic friction and that they can be calculated even in the region where metallic contact occurs. He assumes that in this region film friction still remains between the asperities in contact and that the film supports very high pressures. According to this supposition, the coefficient of friction in this region can be expressed by two terms, referring the first (f_h) to hydrodynamic friction, the second (f_f) to dry friction.

From his previous publication on the 180° journal bearing, author deduces two equations giving ρ 14 (f coefficient of friction, ψ radial relative clearance) as a function of the well-known dimensionless Sommerfeld's combination S_0: one equation for the region of boundary lubrication ($S_0 > 1$); another for the region of film lubrication ($S_0 < 1$). A third equation giving the relative minimum film thickness as a function of S_0 is also deduced from previous work.

With the aid of these three equations and the expression giving the two terms of f, author arrives, for the region of boundary lubrication, at a final expression of f containing also two terms. The first contains the friction coefficient f_0 (for $S_0 = 0$), the combination S_0, and the minimum film thickness. The second term, of small importance, contains only S_0. Author, in this manner, gets for f, in the boundary region, an expression containing S_0. An analysis of the Stribeck curves shows that the value of the minimum thickness depends on the pressure above certain values at which deformation occurs, which increases the value of the minimum film thickness.

An example, in which the value of f_0 and the variation of the minimum film thickness as a function of S_0 in the boundary region are assumed to be known, shows the method of calculating f in function of S_0 in the two regions.

The results and the opinions of several authors are discussed at the end of the paper.

D. De Meulemeester, Belgium

347. **DuBois, G. B., Ocvirk, F. W., and Wehe, R. L., Experimental investigation of eccentricity ratio, friction, and oil flow of long and short journal bearings with load-number charts,** *NACA TN* 3491, 63 pp., Sept. 1955.

The performances of plain bearings under steady central loading are compared and summarized by single-line curves covering

the range of length-diameter ratios both above and below 1. Experimental data on eccentricity ratio, friction, and oil flow for length-diameter ratios of 1, 1-1/2, and 2 are shown for comparison with earlier data for length-diameter ratios of 1/4, 1/2, and 1. The combined data provide charts of plain-bearing performance which cover the practical range of length-diameter ratio.

The load number $1/C_n$ in the form $p/\mu N'(c_d/d)^2(d/l)^2$, where C_n is the capacity number, p the central unit bearing load, μ the oil viscosity, N' the journal speed, c_d the diametral bearing clearance, d the bearing diameter, and l the bearing length, is used as the basic variable on which eccentricity, friction, and oil flow rate depend. Charts are presented to show that the eccentricity-ratio data fall nearly on a single line for both long and short bearings if the $(d/l)^2$ term in the load number is taken as unity for bearings of l/d greater than 1; in effect, the load number for long bearings becomes the reciprocal of the Sommerfeld number $1/S$. Friction and oil flow rate, however, are shown to depend on the load number without this modification, for both long and short bearings.

Plots of friction data in terms of friction ratio F/F_0 are presented to focus attention on the difference between journal friction and bearing friction. Experimental journal-friction data from other sources are included.

Analytical curves by Sommerfeld, Cameron, and Wood and the short-bearing approximation are shown for comparison with the experimental data for eccentricity ratio and friction. Curves resulting from the integration of Sommerfeld's pressure-distribution function for an extent of 180° of the pressure film are also shown. From authors' summary

Marine Engineering Problems

(See also Revs. 67, 306)

348. Seventh International Conference on Ship Hydrodynamics, *Swedish State Shipbldg. Exper. Tank Rep.* no. 34, Aug. 20–31, 1954.

This report of 333 pages contains formal committee reports on five sections, and the formal as well as the free discussions of these reports by delegates of seventeen nations represented at this Conference. This is followed by the Standing Committee Report and by the decisions and recommendations made by the Conference, the principal ones of which are the following:

I. Scale effects on propellers and on self-propulsion factors: The experimental technique of each participating ship model basin should be re-examined in the light of the results of the full-scale "Victory" ship comparative tests. Work on the subjects of scale effects concerning propeller, wake, and thrust deduction should be encouraged and methods devised to reach a practical solution of these problems. Attention should be given to the influence of turbulence and of the presence of the rudder in the propeller flow.

II. Skin friction and turbulence stimulation: Any proper correlation of model and ship resistance data should take account of the effects of three-dimensional flow and other causes of variable extrapolation. A good engineering solution for the formulation of skin friction based on Reynolds number is urgently required.

III. Comparative cavitation tests of propellers: The influence of tunnel walls should be determined more definitely by a cooperative test program. A better correlation between open-water and tunnel-test results should be obtained. Tests of one propeller are to be arranged in all establishments with an identical method of measuring flow velocity and at atmospheric pressure at center of shaft. The degree of turbulence of tunnel flow should be established, as well as the effect of nuclei and entrained air.

IV. Seagoing qualities of ships: Comparative tests of ship models in regular waves should be pursued with emphasis on obtaining similar conditions in all tanks, such as: (a) Accuracy in producing and measuring waves; (b) accuracy in measuring speed, resistance, and motions of model; (c) obtaining steady conditions; (d) identical wave-lengths range for similar waves in all tanks. At least two full cycles of behavior; (e) continuous records of pitch and heave and of phase angles between waves and model motions; (f) accuracy in the geometric similarity of models and turbulence stimulation devices; (g) uniformity in testing methods either with constant resistance or with constant mean speed for each set of tests. Experimental and theoretical investigations for studying wall effect and influence of length of initial run are to be encouraged.

V. Presentation of resistance and propulsion data: Presentation methods should be nondimensional, simple, and facilitate practical application. Attention should be paid to the compatibility of the parameters adopted. L. Troost, USA

349. Emerson, A., The application of wave resistance calculations to ship hull design, *Quart. Trans. Instn. nav. Arch. Lond.* **96**, 3, 268–283, July 1954.

Paper indicates the type of correction needed to bring calculated and measured wave resistances into reasonable agreement. It is very desirable that the same result should be obtained by correction to the mathematical treatment. If this is not possible, then the correction factors can be obtained from a study of wave profiles on selected models, or, for design purposes, simply derived from the mass of model data in existence.

This trespass on the mathematical territory has been made solely because of the conviction that the present reliance on model testing alone not only makes for slow progress, but is inherently dangerous. From author's summary

350. Baker, R., The form and stability of ships, *Inter. Shipbldg. Progr.* **2**, 12, 368–383, 1955.

Biomechanics

351. Hatch, T. F., Proposed program in ergonomics (Human Engineering), ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-238, 4 pp.

Please Note

The Subject and Author Indexes to APPLIED MECHANICS REVIEWS, Vol. 8, January–December, 1955, are to be published in separate pamphlet form and will be mailed together with the February, 1956, issue APPLIED MECHANICS REVIEWS.